Journal of the Royal Society of Arts

NO. 5028 NOVEMBER 1958 VOL. CVI

FORTHCOMING MEETINGS

WEDNESDAY, 5TH NOVEMBER, at 2.30 p.m. INAUGURAL ADDRESS. '*The Challenge of the Future*', by Sir Alfred Bossom, Bt., LL.D., F.R.I.B.A., J.P., M.P., Chairman of Council. (Tea will be served after the meeting.)

WEDNESDAY, 12TH NOVEMBER, at 2.30 p.m. *Modernizing the Railways—Motive, Power and Operation*', by Cecil J. Allen, M.Inst.T., A.I.Loc.E.

WEDNESDAY, 19TH NOVEMBER, at 2.30 p.m. CADMAN MEMORIAL LECTURE. '*Improving the Efficiency of the Mining Industry*', by L. A. Longden, B.Sc., A.M.I.C.E., F.G.S., Director-General of Production, National Coal Board, and President, Institution of Mining Engineers. Sir James Bowman, K.B.E., J.P., Chairman, National Coal Board, in the Chair.

MONDAY, 24TH NOVEMBER, at 6 p.m. The first of three CANTOR LECTURES on '*The Aeroplane*': '*The Birth of the Aeroplane*', by C. H. Gibbs-Smith, M.A., Keeper of Extension Services, Victoria and Albert Museum.

WEDNESDAY, 26TH NOVEMBER, at 2.30 p.m. '*Style and Era in Church Melody: an Historical Survey*', by the Rev. Canon Greville Cooke, M.A., Mus.B., Professor and Fellow, Royal Academy of Music. W. Greenhouse Allt, D.Mus., F.R.C.O., F.T.C.L., Principal, Trinity College of Music, in the Chair.

FRIDAY, 28TH NOVEMBER, at 7.30 p.m. FILM EVENING. (See programme following.)

MONDAY, 1ST DECEMBER, at 6 p.m. The second of three CANTOR LECTURES on '*The Aeroplane*': '*The Development of the Aeroplane*', by Peter W. Brooks, B.Sc.(Eng.), A.C.G.I., A.F.R.Ae.S., Technical Assistant to the Chairman, British European Airways.

WEDNESDAY, 3RD DECEMBER, at 2.30 p.m. '*The Consulting Engineer and his Contribution to the National Economy*', by Julian S. Tritton, M.I.C.E., M.I.Mech.E., President, International Federation of Consulting Engineers. J. K. Vaughan-Morgan, M.P., Minister of State, Board of Trade, in the Chair.

MONDAY, 8TH DECEMBER, at 6 p.m. The last of three CANTOR LECTURES on '*The Aeroplane*': '*The Future of the Aeroplane*', by Eric Mensforth, C.B.E., M.I.Mech.E., F.R.Ae.S., Chairman, Westland Aircraft, Ltd.

WEDNESDAY, 10TH DECEMBER, at 2.30 p.m. *'Large Scale Organization and Change: a Study in Oil Marketing'*, by Christopher T. Brunner, Director of Marketing, Shell-Mex & B.P., Ltd., and a Member of Grand Council, Federation of British Industries. Sir Arnold Plant, Sir Ernest Cassel Professor of Commerce, University of London, in the Chair.

TUESDAY, 16TH DECEMBER, at 5.15 p.m. COMMONWEALTH SECTION. *'Land Utilization in the Commonwealth'*, by L. Dudley Stamp, C.B.E., D.Lit., D.Sc., Director, Land Utilization Survey of Britain. R. O. Buchanan, M.A., B.Sc.(Econ.), Ph.D., Professor of Geography, the London School of Economics and Political Science, in the Chair. (Tea will be served in the Library from 4.30 p.m.)

Fellows are entitled to attend any of the Society's meetings without tickets (except where otherwise stated), and may also bring two guests. When they cannot accompany their guests, Fellows may give them special passes, books of which can be obtained on application to the Secretary.

FILM EVENING

The first Film Evening of the Session will be held at the Society's House on Friday, 28th November, at 7.30 p.m., when the following films will be shown:

Timeless Temiar
Renaissance
Begone Dull Care

Timeless Temiar (47 minutes), filmed in Eastmancolour, portrays the communal life and ceremonial rites of the peaceful and friendly Temiars, the largest aboriginal tribe in Malaya. It was produced by the Malayan Film Unit and has been selected for showing at a number of the more recent film festivals.

Renaissance (25 minutes) is a beautiful art film in colour sponsored by Encyclopædia Britannica. The genesis and development of this great movement are related through pictures of its topographical background and major works of art. The film devotes a long sequence to the della Robbia reliefs of singing and dancing children, and examines the scientific achievements of da Vinci, as well as depicting something of the harsher side of life at this time.

Begone Dull Care (9 minutes), filmed in Kodachrome, is another of the experimental productions painted directly on film by Norman McLaren and Evelyn Lambert. It is a clever and sophisticated essay in the interpretation of musical mood by means of fluid lines and colour. The music, mostly jazz, is played by the Oscar Peterson Trio.

Tickets are not required for this Film Evening and Fellows are invited to bring two guests. Light refreshments will be served in the Library after the performance.

INCOME TAX RELIEF ON ANNUAL SUBSCRIPTIONS

The following letter has been received from the Commissioners of Inland Revenue:

INLAND REVENUE
Chief Inspector of Taxes Branch
New Wing, Somerset House,
London, W.C.2.

In any reply please quote:
C.L./SUB/206

8th October, 1958

DEAR SIR,

I have to inform you that the Commissioners of Inland Revenue have approved The Royal Society of Arts for the purposes of Section 16, Finance Act, 1958, and that the whole of the annual subscription paid by a member who qualifies for relief under that Section will be allowable as a deduction from his emoluments assessable to income tax under Schedule E. If any material relevant change in the circumstances of the Society should occur in the future you are requested to notify this office.

I should be glad if you would inform your members as soon as possible of the approval of the Society. The circumstances and manner in which they may make claims to income tax relief are described in the following paragraphs, the substance of which you may care to pass on to your members.

Commencing with the year to 5th April, 1959, a member who is an office holder or employee is entitled to a deduction from the amount of his emoluments assessable to income tax under Schedule E of the whole of his annual subscription to the Society *provided that*—

(*a*) the subscription is defrayed out of the emoluments of the office or employment, and

(*b*) the activities of the Society so far as they are directed to all or any of the following objects—

(i) the advancement or spreading of knowledge (whether generally or among persons belonging to the same or similar professions or occupying the same or similar positions);

(ii) the maintenance or improvement of standards of conduct and competence among the members of any profession;

(iii) the indemnification or protection of members of any profession against claims in respect of liabilities incurred by them in the exercise of their profession;

are relevant to the office or employment, that is to say, the performance of the duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession concerned.

A member of the Society who is entitled to the relief should apply to his tax office as soon as possible after 31st October, 1958, for Form P358 on which to make a claim for adjustment of his pay as you earn coding.

Yours faithfully,

The Secretary,
The Royal Society of Arts.

(Sgd.) T. DUNSMORE,
Senior Principal Inspector of Taxes.

Claims for income tax relief in accordance with the terms of this ruling are, of course, a matter for private negotiation between Fellows and their local tax officers, and it will be appreciated that the Secretary is not able to act as an intermediary in this matter.

RESULTS OF THE OFFER OF ENDOWED PRIZES

In accordance with the terms of certain bequests, the Society this year offered two prizes under the terms set out below. The results of these offers are now announced:

1. *Fothergill Prize for Fire Prevention or Fire Fighting*

A prize of £20 was offered for a descriptive essay or model embodying some new idea for the prevention or suppression of fire.

Six entries were received. In the view of the judge, Mr. D. I. Lawson, Director, D.S.I.R. Fire Research Station, the entry which came nearest to the requirements of the competition was that by Mr. E. C. Simpson, G.I.Fire E., in which he advocates the use of 'Special Hydrant-Indicating Nails'. This idea is very practicable, but it has a rather limited scope in the field of fire prevention, and the Council has decided that the prize awarded to Mr. Simpson should be one of £10. His essay will be printed in the next issue of the *Journal*. (It may be remembered that Mr. Simpson was adjudged to be the runner-up in last year's Fothergill Prize Competition.)

The Council has also decided that the entry by Mr. C. E. Brunt, G.I.Fire E., F.I.C.D., 'Keep Fire off the Roads', in which the author incorporates a number of suggestions for fire prevention in motor vehicles, should be commended.

2. *Howard Prize for Mechanical Motive Power*

A prize of £50 was offered for a treatise on some aspect of the subject of motive agents.

No entries were received.

CHAIRMAN OF COUNCIL'S VISIT TO NORTH AMERICA

As announced in the last issue of the *Journal*, the Chairman took advantage of the Parliamentary Summer Recess to go to North America and there contact as many members of the Society as possible. He visited Toronto and Ottawa, and with the aid of Colonel Brown and Mr. Stanley Conder in Canada and Professor Lissim in New York met a large number of members who, in many cases, came from quite considerable distances. Among other places, the Chairman also visited the Franklin Institute in Philadelphia, and there met a number of Fellows of the Society. Without exception, they all expressed marked enthusiasm for the Society and particularly for the *Journal*, and all hoped that the membership would greatly increase in the near future.

They were pleased to hear that Dr. Luckhurst was shortly going to make a rather protracted visit to Canada and the United States after the hot season was over, so that many of the Fellows who would otherwise have been on holiday would be back to meet him. Dr. Luckhurst is now in the midst of this visit, and from the reports he sends back he is finding that members are most enthusiastic and that they consider it an honour to belong to the Society. In due course there will be published in the *Journal* a full account of his visit.

INDUSTRIAL ART BURSARIES EXHIBITION

The Exhibition of designs submitted in the 1957 Industrial Art Bursaries Competition is on view at the Stoke-on-Trent College of Art until 28th October. From 3rd to 14th November the Exhibition may be seen at the Kingston-upon-Hull College of Art and Crafts, Anlaby Road, Hull.

SESSIONAL ARRANGEMENTS

A list of the meetings so far arranged for the forthcoming session is included as a supplement in this issue of the *Journal*.

MEETING OF COUNCIL

A meeting of Council was held on Monday, 13th October, 1958. Present: Sir Alfred Bossom (in the Chair); Mrs. Mary Adams; Sir Hilary Blood; Mr. R. E. Dangerfield; Sir George Edwards; Mr. P. A. Le Neve Foster; Mr. John Gloag; Sir Ernest Goodale; Sir William Halcrow; Dr. R. W. Holland; Lord Latham; Mr. Edgar E. Lawley; Sir Harry Lindsay; Mr. F. A. Mercer; Mr. O. P. Milne; Lord Nathan; Sir Gilbert Rennie; Mr. A. R. N. Roberts; Sir Selwyn Selwyn-Clarke; Professor S. Tolansky; Mr. G. E. Tonge; Mr. Hugh A. Warren; Sir Griffith Williams, and Miss Anna Zinkeisen; with Mr. G. E. Mercer (Deputy Secretary) and Mr. J. S. Skidmore (Assistant Secretary).

ELECTIONS

The following candidates, whose applications had been received since the last meeting in July, were duly elected Fellows of the Society:

Alexander, Ernest Alfred Sanders, London.
Aldridge, Thomas Jack, B.Sc., D.I.C., A.C.G.I., M.I.E.E., London.
Ashby, Robert Leslie, London.
Aucken, Julian Mordecai, B.A., London.
Awopeju, Joshua Olufumiwa, B.A., LL.B., London.
Bale, Anthony Powis, M.I.Mech.E.,Thames Ditton, Surrey.
Barbour, Archibald Buchanan, O.B.E., O.St.J., M.R.C.S., L.R.C.P., F.R.Ae.S., Cookham Dean, Berks.
Belgiojoso, Professor Lodovico Barbiano di, Dr. Arch., Milan, Italy.
Bercow, Samson, London.
Berkner, Lloyd Viel, B.S., Ph.D., D.Sc., New York, U.S.A.
Burton, Professor Donald, M.B.E., D.Sc., F.R.I.C., Leeds.
Bushill, John Herbert, D.Sc., F.R.I.C., Surbiton, Surrey.
Carleton, John Dudley, M.A., London.
Carstairs, Charles Young, C.M.G., Reigate, Surrey.
Charley, Vernon Leslie Smith, B.Sc., Ph.D., Coleford, Glos.
Chirnside, John, Stockport, Cheshire.
Cole, Lieut.-Colonel Howard Norman, O.B.E., T.D., F.R.Hist.S., Farnham, Surrey.
Collicott, Mervyn Thomas, Plymouth, Devon.
Cooke, Stanley Peter, London.
Cooper, David John, B.Sc., Doncaster.
Cortlandt, Miss Lyn, New York, U.S.A.

Davies, Geoffrey Llewellyn, London.
Davies, Stanley Kenneth, C.B.E., Cardiff.
Dean, Gordon, Bradford.
de Erdely, Professor Francis, A.W.S., California, U.S.A.
Drinker, Henry Sandwith, LL.B., Mus. Doc., Litt.D., Philadelphia, Pa., U.S.A.
Duncan, David Currie, Welwyn Garden City, Herts.
Dunwoody, Thomas, Eastcote, Middx.
Dykes-Brown, Cyril, M.I.E.E., Hatch End, Middx.
Earley, Robert Frederick, B.Sc., M.I.C.E., Stevenage, Herts.
Egerton, Seymour John Louis, London.
Elder, Hugh, M.A., Northwood, Middx.
Evans, Frank Alfred, Banstead, Surrey.
Facius, Ronald Eric, London.
Farrell, John Kevin Anthony, M.A., Ph.D., London, Ontario, Canada.
Fawcett, Cyril Herbert, M.Sc., Ph.D., Ashford, Kent.
Fernald, John Bailey, London.
Firth, Alan, Stafford.
Foster, Claude Ernest Walker, Pietermaritzburg, Natal, South Africa.
Galustian, Haig Caro, London.
Gibbs, William Francis, M.A., LL.B., Eng.D., Sc.D., New York, U.S.A.
Gray, Gordon Latimer, B.Agric., Pinner, Middx.
Harbron, John Davison, M.A., Toronto, Ontario, Canada.
Hench, Christopher John George, Mitcham, Surrey.
Hodgson, Henry Wigston, A.L.A., Carlisle, Cumberland.
Hollingsworth, Miss Dorothy Frances, O.B.E., B.Sc., F.R.I.C., Orpington, Kent.
Horne, Edgar, Ph.C., F.P.S., Sale, Cheshire.
Hoyte, Rupert Leon, St. George's, Grenada, B.W.I.
Hammer, Lieut.-Colonel Norman William, T.D., L.R.C.P., M.R.C.S., Edgware, Middx.
Harte, Aldo Harold Worringham, M.A., Ph.D., Christchurch, New Zealand.
Hyslop, George Douglas, N.D.D., Maghull, Lancs.
Jackson, Peter Charles, Penryn, Cornwall.
James, Dennis Frederick, A.M.I.C.E., Wallington, Surrey.
Knapper, Charles, F.R.I.B.A., Stoke-on-Trent.
Latto, Douglas, M.B., Ch.B., London.
Lee, Colin, LL.B., Manchester.
Lemmer, John Richard, Sanderstead, Surrey.
Lenney, Miss Annie, West Caldwell, New Jersey, U.S.A.
Leonard, James Theodore, Woodford Green, Essex.
MacGregor, Colin, London.
McNarry, Donald William, New Milton, Hants.
Maddieson, Henry Ray, Romney Marsh, Kent.
Marriott, William Rhodes, Stockport, Cheshire.
Marston, Hedley Ralph, D.Sc., F.R.S., St. Peters, South Australia.
Miller, Isaac Pritchard, B.L., N.P., Greenock, Renfrewshire.
Miller, Harvey Israel, M.A., London.
Milner, Dennis Frank, Hull.
Morris, Harold, London.
Morton, James Dickie, B.Sc., M.I.Mech.E., M.I.E.E., Northwood, Middx.
Nevell, Stanley Robert, London.
Olaseinde, Festus Oladele, Ondo, Nigeria.
Pelerin, Lawrence Norman, F.C.I.I., Tunbridge Wells, Kent.
Phillips, Gordon Albert Edward, Christchurch, Hants

Pirazzoli, Professor Marco Aurelio, Bologna, Italy.
Ramamurti, Professor Krishnamurti, M.A., B.Sc., A.R.I.C., Manchester.
Ray, Gilbert, A.R.I.B.A., Haverfordwest, Pembs.
Redman, Lieut.-General Sir Harold, K.C.B., C.B.E., Chichester, Sussex.
Robbins, Edward Leslie Gifford, B.Sc., A.C.G.I., M.I.Mech.E., Stanmore, Middx.
Roberts, Eric John, Backwell, Somerset.
Ross, John Broadbent, F.R.I.C., Newcastle-on-Tyne.
Ross, Kenneth Brebner, O.B.E., M.A., B.Sc., Kelsall, Cheshire.
Russell, Patrick, B.Sc., Meopham, Kent.
Scott, Brian, Leeds.
Smith, Clifford Douglas, Wroughton, Wilts.
Snow, Frederick Sidney, C.B.E., M.I.C.E., London.
Spicer, Leopold William, London.
Splatt, William James, Caulfield North, Victoria, Australia.
Stone, Charles Bernard, D.S.O., B.Sc., M.I.C.E., Sanderstead, Surrey.
Summers, Eric William, Bexleyheath, Kent.
Tatman, Norman James, M.I.C.E., London.
Vann, Alfred Ernest, London.
Walia, Saranjit Singh, Nairobi, Kenya.
Walmsley, John, Burnley, Lancs.
Ward, Clark Raymond, Ph.B., Ph.C., Dayton, Ohio, U.S.A.
Webster, John, Romney Marsh, Kent.
West, Trustram Frederick, D.Sc., Ph.D., London.
Whyte, Ralph Garioch, Bromley, Kent.
Wilson, Colonel John Skinner, C.M.G., O.B.E., Maidstone, Kent.
Woodgate, Frederick James, Tamworth, New South Wales, Australia.
Woolley, Sidney Victor, M.I.Mech.E., New Malden, Surrey.
Wornum, Mrs. Miriam, San Francisco, California, U.S.A.
Wynne, David, London.
Yearsley, Major Ralph Algernon, Hythe, Kent.

The following were elected Associate Members:

Leggat, Robert Sim, Ilford, Essex.
Morrison, Trevor Gordon Lamont, Strathaven, Lanarks.
Shahani, Prem Kevalram, London.

The following was admitted as an Institution in Union:

The Library, The University, Nottingham.

SWINEY CUP

Approval was given to a design for the 1959 Swiney Cup by Mr. David Mellor, Des.R.C.A.

INDUSTRIAL ART BURSARIES COMPETITION

It was agreed that an additional award, endowed by the firm of George M. Whiley Ltd., and with an annual value of £150, should be offered in the next, and succeeding, competitions.

NATIONAL ADVISORY COUNCIL ON ART EXAMINATIONS

Mr. A. B. Read, R.D.I., was appointed as the Society's representative on the National Advisory Council on Art Examinations.

OTHER BUSINESS

A quantity of financial and other business was transacted.

REPORT ON THE SOCIETY'S EXAMINATIONS FOR THE SESSION 1957-1958*

INTRODUCTION

The motto of the Society, displayed over the entrance door of its House in John Adam Street, is

'Arts and Commerce Promoted'.

In furthering that object, the Society has always adopted an 'opportunist' attitude—not in the sense of snatching easy advantage or profits but in the sense of doing something which needed to be done but which lacked an active promoter.

It was in that spirit that in 1856 the Society organized—for its affiliated Institutes—a comprehensive programme of examinations in Mathematics, Book-keeping, Science, Agriculture, Languages, etc.; in 1873 the new field of 'technological subjects' was opened; later again the School Commercial Certificate, and finally in 1958—at the instigation of secondary modern schools throughout the country—the School Certificate with general, commercial, and technical options.

To the visitor from abroad, the spectacle of an independent corporate body such as the Royal Society of Arts pursuing its own way and its own examination policy, outside the direct administrative control of either the Ministry of Educations or the Local Education Authorities, may seem a strange anomaly. Stranger still, perhaps, is the fact that those bodies, whose powers—the visitor thinks—have been usurped, are in fact co-operating, in a spirit of good will, in the work of the Society, giving advice through representatives on the Examinations Committee and on its various syllabus sub-committees! Such a system, however, allows much freedom to experiment outside the narrow confines of direct official control and it enables many needs to be met which would go by default in a more rigid or more standardized system.

In fact, when the 'pioneer' stage is over or a section of the examination system is ready for transfer to a more appropriate body the Society is not slow to relinquish control. It was in such a spirit that the 'technological subjects' were handed over to the infant City and Guilds of London Institute after its foundation in 1878. The Society, already 124 years old, had by then discharged its habitual rôle of 'fairy godmother', and had created a large new educational province, ripe for transfer.

Looking to the future, what new contributions can the Society expect to make in this field of examinations? Already the new 'generalized' form of the School

* A fuller report, containing lists of prizewinners and medallists, and the individual reports of the Examiners in the various subjects, will be published as a separate pamphlet by the Examinations Department later this year, and a copy of it may be obtained by Fellows on application to the Examinations Officer.

Certificate is showing signs of lusty growth, providing a type of examination that will be moulded and re-moulded—always upon advice of those with first-hand knowledge—to suit the needs of those pupils in various types of secondary schools who do not find the General Certificate of Education a suitable, or even an attainable qualification. The prestige that has long attached to the School Commercial Certificate has now been extended to the School Technical and School 'General' Certificate.

The 'grouped course' certificates—originally intended for part-time and evening students, but used also by full-time day schools—will still be awarded and will provide yet another examination option for the multi-sided activities of the present-day secondary schools.

The Society's historical interest in the apprentice—both industrial and commercial—and his or her educational needs may well find future expression in connection with the increasing work of 'Day Colleges' (embryo County Colleges), in particular with the 'non-vocational' part-time studies of these young workers.

The resurgence of interest in European modern languages, owing to fast-growing European trade and other organizations—Common Market, Euratom, O.E.E.C., W.E.U., N.A.T.O., Council of Europe, etc.—will undoubtedly widen the scope of the Society's language examinations and possibly affect their character.

The Society, whilst being a corporate body under Royal Charter, is not, in the modern sense, a 'professional institution'; its examinations are not concerned with admission to membership, its interests are as multifarious as human activity itself, its membership shows a complete cross-section through all professions, and the Society has no commercial interests to limit its viewpoint. These peculiar attributes, unique in the world of to-day, permit the Society to conduct its examination system in a spirit of freedom, to enjoy the trust of central and local education authorities, and to receive the benefit of their advice and support.

The need for, and extent of, the Society's examinations may be readily appreciated from the Summary of Entries in the following Report. But these are mere figures and tell us nothing of the human side—the candidate, the examiner, the syllabus committee, the local centre, the Society's officers and their good work. That aspect of the story is dealt with in part in the Examiners' Reports but is more fully known to the many educationists who are now actively associated with the Society's work as members of committees, as examiners, or in other similar capacities. To all these, and to the many heads of schools and teachers who maintain contact with these examinations, the Council of the Society is deeply grateful.

HUGH A. WARREN

ENTRIES AND PAPERS WORKED

The following table gives a detailed comparison of the subject-entries for the various examinations conducted by the Society in the Sessions 1957–1958 and 1956–1957, and also of the papers worked:

Examination	*Entries*		*Papers Worked*	
	1957–1958	1956–1957	1957–1958	1956–1957
Ordinary (Single-Subject)	203,306	175,479	192,756	166,224
School and Senior School Certificates ...	31,603	17,862	31,380	17,297
Oral Tests	6,249	5,073	5,928	4,738
Grouped Course	25,637	18,455	24,783	17,412
Teacher's Certificate in Shorthand	753	751	733	710
Teacher's Certificate in Typewriting	492	376	478	371
Road Transport Subjects	1,352	1,292	1,242	1,197
British Transport Commission (Preliminary Examination of Candidates under Apprenticeship Schemes)	1,011	1,187	973	1,155
Royal Air Force Administrative Apprentices (Endorsement of certificates awarded by the Air Ministry)	101	105	101	105
British European Airways (Special proficiency tests in Shorthand and Typewriting) ...	—	126	—	109
Totals ...	270,504	220,706	258,374	209,318

GENERAL REMARKS

During the present Session the number of subject-entries has, for the first time, exceeded a quarter of a million. The actual total of 270,504 was greater by 49,798 than the total for 1957.

In recent years there has been a marked increase in the demand for the Society's examinations, and since 1952 the numbers have more than doubled, as will be seen from the following list:

1952 130,132 subject entries
1953 142,670 ,,
1954 155,341 ,,
1955 178,450 ,,
1956 194,000 ,,
1957 220,706 ,,
1958 270,504 ,,

This ever-increasing demand is very gratifying indeed, not only to the Council and officers of the Society but also to the examiners and moderators, and to the members of the numerous committees who have given their time and valuable advice in the preparation of the regulations and syllabuses, etc. The very large increase this year is spread over the three main types of examinations offered by the Society, and it would appear that these are obviously meeting a need, and meeting it to the general satisfaction of those concerned with education in all parts of the United Kingdom and in certain territories in the British Commonwealth.

ORDINARY (SINGLE-SUBJECT) EXAMINATIONS

The additional entries for these examinations were spread over not only the four separate Series (Easter, Whitsun, Summer, and Autumn) but also most of the subjects. The largest increases were in Typewriting, Shorthand, English Language, and Arithmetic. For the Summer Series alone there were over 100,000 subject-entries, including nearly 16,000 from candidates in Nigeria, and it is interesting to recall that this is approximately equivalent to the total of entries for the four separate Series in 1952.

SCHOOL CERTIFICATE EXAMINATIONS

Last year there was instituted a scheme of examination for the award of a School Technical Certificate similar in structure and general aim to that for the School Commercial Certificate which had been offered since 1927. The new certificate was designed essentially for boys, and this resulted in a large number of requests for the scheme to be extended still farther by the inclusion of general and domestic subjects more suitable for girls. In these circumstances, the requirements for the Society's school examinations were considered by a specially appointed committee, and a revised and comprehensive scheme was instituted this year covering general, commercial, domestic, and technical subjects. Candidates are required to enter for a minimum of five subjects, and are awarded a School Certificate if they pass in English Language and any four additional subjects, or a School Certificate (Commercial) or a School Certificate (Technical) if they pass in English Language plus four additional subjects from prescribed groups; candidates failing to get the full certificate receive a certificate stating the subjects in which they have been successful.

This comprehensive scheme of examination, with a pass level approaching the standard of the former General School Certificate examinations, has been warmly welcomed by school authorities in all parts of the United Kingdom, and entries were received from 3,823 candidates; for the Senior School Commercial Certificate there were 81 entrants. The total number of subject-entries was 26,340. In addition, in Nigeria there have this year been 808 candidates for the examinations for the School Certificate (Commercial) and 56 for those for the Senior School Commercial Certificate; the numbers of subject-entries were 4,952 and 311 respectively, as against 2,987 and 1,477 in 1957.

The examinations for the Senior School Commercial Certificate will be offered so long as there is a sufficient demand for them.

The Society has now approved a temporary relaxation of the regulation whereby candidates for the School Certificate examinations are required to enter for not less than five subjects, including English Language. This has been arranged for the benefit of a number of secondary schools which, in their present period of development, find that the existing minimum requirements for entry are too exacting. In 1959–1963, inclusive, candidates will be permitted to enter for not less than four subjects, including English Language; they will not be eligible for the award of the full School Certificate but they will be issued with a certificate stating the subjects in which they have been successful. For this concession there is no reduction in the basic fee.

GROUPED COURSE

It was thought that the new scheme of examination for the award of a School Certificate might reduce the demand from secondary schools for the Grouped Course examinations, but this has not been the case and the entries, from day and evening classes, went up from 18,455 in 1957 to 25,637 in 1958.

TEACHER'S CERTIFICATE IN SHORTHAND

At the examination in November, 1957, there were 233 candidates, of whom 103 passed in all sections and 2 were 'referred' in the Speed Test only; in addition, 15 were granted exemption from Part I and 9 from Part II. This exemption is allowed at the discretion of the Panel and is conditional upon completion of the examination by the candidate within twelve months. In May, 1958, there were 500 candidates, of whom 197 passed in all sections and 8 were 'referred' in the Speed Test only; in addition, 49 were granted exemption from Part I and 5 from Part II.

TEACHER'S CERTIFICATE IN TYPEWRITING

At the examination in November, 1957, there were 169 candidates, of whom 79 passed in all sections, 22 were granted exemption from Part I, and 4 from Part II. In May, 1958, there were 309 candidates, of whom 157 passed in all sections, 31 were granted exemption from Part I, and 8 were granted exemption from Part II.

OTHER EXAMINATIONS

There was a slight increase—from 1,292 to 1,352—in the number of entries for the examinations in Road Transport Subjects. These are organized by the Society in conjunction with the National Committee on Road Transport Education. The special examinations in connection with apprenticeship schemes of the British Transport Commission were held in May, 1958, and those for the endorsement by the Society of certificates awarded by the Air Ministry to Royal Air Force Administrative Apprentices were held in November, 1957, and March and July, 1958.

BRITISH EUROPEAN AIRWAYS

The special arrangements under which the Society has, since 1951, conducted proficiency tests in shorthand and typewriting for employees of British European Airways, have been discontinued. In view of changing organization, including the introduction of audio-typists, the small numbers of candidates for the proficiency tests will in future be dealt with internally.

EXAMINATIONS IN SECONDARY SCHOOLS

In January, 1958, the Society submitted a letter to the Central Advisory Council for Education (England) as the Minister of Education (*vide* Ministry of Education Circular 326) had remitted to that body questions of principle affecting examinations in secondary schools. This letter summarized the various approaches on this subject which had been made to the Minister by the Society in recent years, including the suggestion that secondary-school pupils in their sixteenth year should, at the discretion of head teachers, be permitted to take certain external examinations such as those conducted by the Society and other suitable bodies. With this letter was sent a factual statement on those examinations of the Society which were suitable for, and taken by, secondary-school pupils. No detailed reply has yet been received.

ASSOCIATE MEMBERSHIP

Four Silver Medallists at the Society's examinations in 1957 have been elected to Associate Membership.

GROUPED COURSE EXAMINATIONS, 1958, IN THE ADMINISTRATIVE COUNTY OF LONDON

COMMERCIAL AND GENERAL GROUPS—STAGE I

Subjects	*Passed with Credit*			*Passed*			*Not Passed*			*Papers worked at Whitsun and Summer combined*
	Whit-sun	*Sum-mer*	*Total*	*Whit-sun*	*Sum-mer*	*Total*	*Whit-sun*	*Sum-mer*	*Total*	
Arithmetic	5	5	10	5	16	21	14	86	100	131
Arithmetic & Accounts	4	2	6	6	10	16	17	40	57	79
Commerce	3	9	12	22	73	95	10	55	65	172
Economic Geography	—	3	3	11	15	26	31	39	70	99
English Language ...	26	32	58	82	276	358	15	149	164	580
French	3	4	7	13	16	29	21	27	48	84
History	1	—	1	19	7	26	6	13	19	46
Shorthand, 50 w.p.m.	—	5	5	3	13	16	20	158	178	199
,, 60 ,,	1	—	1	3	6	9	6	37	43	53
Typewriting	8	47	55	10	84	94	21	231	252	401
Totals	51	107	158	174	516	690	161	835	996	1,844

COMMERCIAL AND GENERAL GROUPS—STAGE II

Subjects	*1st Class*			*2nd Class*			*Not Passed*			*Papers worked at Whitsun and Summer combined*
	Whit-sun	*Sum-mer*	*Total*	*Whit-sun*	*Sum-mer*	*Total*	*Whit-sun*	*Sum-mer*	*Total*	
English Language ...	—	1	1	—	5	5	—	5	5	11
Shorthand, 80 w.p.m.	—	—	—	—	4	4	2	3	5	9
,, 100 ,,	—	—	—	—	—	—	—	—	—	—
Typewriting	—	—	—	—	1	1	2	15	17	18
Totals	—	1	1	—	10	10	4	23	27	38

TECHNICAL GROUP

Subjects	*Passed with Credit*			*Passed*			*Not Passed*			*Papers worked at Whitsun and Summer combined*
	Whit-sun	*Sum-mer*	*Total*	*Whit-sun*	*Sum-mer*	*Total*	*Whit-sun*	*Sum-mer*	*Total*	
English	49	70	119	175	518	693	105	157	262	1074
Mathematics	187	183	370	102	277	379	60	184	244	993
Science	114	126	240	95	155	250	47	98	145	635
Technical Drawing ...	70	123	193	86	214	300	127	263	390	883
Trade Calculations ...	—	5	5	6	35	41	27	117	144	190
Totals	420	507	927	464	1199	1663	366	819	1185	3,775

GROUPED COURSE EXAMINATIONS, 1958, AT CENTRES OUTSIDE THE COUNTY OF LONDON

COMMERCIAL AND GENERAL GROUPS—STAGE I

Subjects	*Passed with Credit*			*Passed*			*Not Passed*			*Papers worked at Whitsun and Summer combined*
	Whitsun	*Summer*	*Total*	*Whitsun*	*Summer*	*Total*	*Whitsun*	*Summer*	*Total*	
Arithmetic	3	9	12	23	15	38	42	85	127	177
Arithmetic & Accounts	1	4	5	5	11	16	9	86	95	116
Commerce	1	2	3	11	46	57	5	70	75	135
Economic Geography	—	2	2	7	18	25	52	138	190	217
English Language ...	41	40	81	65	279	344	6	118	124	549
French	—	1	1	1	11	12	10	43	53	66
History	2	2	4	29	38	67	31	43	74	145
Shorthand, 50 w.p.m.	3	1	4	—	12	12	2	95	97	113
„ 60 „	2	2	4	1	19	20	—	32	32	56
Typewriting ...	4	27	31	3	58	61	7	81	88	180
Totals	57	90	147	145	507	652	164	791	955	1,754

TECHNICAL GROUP

Subjects	*Passed with Credit*			*Passed*			*Not Passed*			*Papers worked at Whitsun and Summer combined*
	Whitsun	*Summer*	*Total*	*Whitsun*	*Summer*	*Total*	*Whitsun*	*Summer*	*Total*	
English	158	193	351	750	1646	2396	328	1197	1525	4272
Mathematics	491	971	1462	408	1066	1474	283	912	1195	4131
Science	465	827	1292	337	979	1316	211	633	844	3452
Technical Drawing ...	194	538	732	428	998	1426	462	939	1401	3559
Trade Calculations ...	150	120	270	197	457	654	257	777	1034	1958
Totals	1458	2649	4107	2120	5146	7266	1541	4458	5999	17,372

EXAMINATIONS IN ROAD TRANSPORT SUBJECTS, 1958

	Papers Worked	*1st Class*	*2nd Class*	*Not Passed*
1st Year—Road Transport Operation (Passenger)	190	25	119	46
,, ,, ,, (Goods) ..	39	3	27	9
Communication and Report Writing ..	224	12	141	71
Road Transport Accounts and Statistics	216	14	129	73
2nd Year—Road Transport Operation (Passenger)	121	28	83	10
,, ,, ,, (Goods) ..	21	2	15	4
Elements of Road Transport Engineering	45	10	27	8
Road Transport Accounts and Statistics	102	6	63	33
3rd Year—Road Transport Operation (Passenger)	87	35	48	4
,, ,, ,, (Goods) ..	23	5	11	7
Road Transport Accounts and Statistics	75	2	31	42
Economics Applied to Road Transport	99	9	51	39
Totals	1,242	151	745	346

SENIOR SCHOOL COMMERCIAL CERTIFICATE EXAMINATIONS, 1958

Candidates, 125; Full Certificates Awarded, 33.

Subjects	*Number of Papers Worked*	*Passed 1st Class*	*Passed 2nd Class*	*Not Passed*
Accounts	118	22	50	46
Arithmetic	90	6	19	65
Commerce	110	7	67	36
English Language	154	12	84	58
English Literature	59	1	27	31
French	23	6	12	5
Geography	43	—	24	19
History	12	1	7	4
History of the British Empire ...	32	7	20	5
†Italian	1	1	—	—
Mathematics	32	7	13	12
*Shorthand, 80 w.p.m.	223	—	118	105
*Shorthand, 100 w.p.m.	9	—	5	4
Typewriting	267	26	94	147
Totals	1,173	96	540	537

† One candidate took the oral test in Italian and passed with distinction.

* In Shorthand at 80/100 w.p.m. there is one class of pass only.

SCHOOL CERTIFICATE EXAMINATIONS, 1958

Number of Candidates, 4,613. *Full Certificates Awarded: School Certificate*, 621; *School Certificate* (*Commercial*), 778; *School Certificate* (*Technical*), 296.

Subjects	*Number of Papers Worked*	*Passed with Credit*	*Passed*	*Not Passed*
Accounts	1,628	114	561	953
Arithmetic	2,856	204	1,508	1,144
Art	71	6	44	21
Biology	106	15	47	44
Chemistry	122	8	33	81
Civics	422	23	176	223
Commerce	2,045	90	1,284	671
Cookery and Nutrition	110	42	56	12
English Language	4,571	387	2,621	1,563
English Literature	1,926	77	1,037	812
*French	488	59	246	183
General Science	696	71	313	312
Geography	2,234	93	771	1,370
Geometrical and Technical Drawing ...	1,302	190	534	578
†German	4	2	—	2
History	1,155	30	471	654
History of the British Empire ...	568	21	190	357
Housecraft	1	—	1	—
Human Biology and Hygiene ...	97	1	42	54
Italian	2	2	—	—
Mathematics Paper A	1,929	423	608	898
Mathematics Paper B	1,513	148	545	820
Mechanics	256	28	63	165
Metalwork (with Drawing)	704	78	414	212
Needlecraft	81	10	54	17
Physics	987	188	346	453
Religious Knowledge	76	12	37	27
Shorthand, 50 w.p.m.	1,055	159	207	689
Shorthand, 60 w.p.m.	613	232	177	204
Spanish	1	—	—	1
Typewriting	1,944	357	646	941
Welsh	44	10	26	8
Woodwork (with Drawing)	600	84	363	153
Totals	30,207	3,164	13,421	13,622

* Fifty candidates took the oral test in French : 16 passed with credit and 18 passed.

† One candidate took the oral test in German but was unsuccessful.

ORDINARY (SINGLE-SUBJECT) EXAMINATIONS

AUTUMN SERIES, 1957, AND EASTER, WHITSUN, AND SUMMER SERIES, 1958

Subject	*Stage*	*Papers worked*	*1st Class (or Passed with Credit in Stage I)*	*2nd Class (or Passed in Stage I)*	*Not Passed*	*Total number of papers worked in each subject* 1958	1957
Accounting	III	80	1	30	49	**80**	135
Advertising	III	28	—	15	13	**28**	26
Arithmetic	I	11,803	1,558	4,270	5,975		
"	II	2,019	161	442	1,416	**14,057**	9,901
"	III	235	25	68	142		
Book-keeping	I	7,970	1,277	2,996	3,697		
"	II	3,668	978	1,237	1,453	**12,560**	11,501
"	III	922	31	294	597		
Cargo Insurance	III	11	1	7	3	**11**	4
Central and Local Government	II	125	4	53	68	**125**	154
Commerce	I	2,831	156	1,281	1,394		
"	II	1,291	20	526	745		
" (Finance) ...	III	206	1	114	91		
" (International Trade)	III	90	—	36	54	**4,442**	3,171
" (Marketing) ...	III	24	—	1	23		
Commercial Law	II	124	6	41	77		
" "	III	33	—	12	21	**157**	214
Common Law	III	8	—	1	7	**8**	13
Company Law	II	42	7	24	11		
" "	III	42	3	21	18	**84**	72
Costing	II	57	6	17	34		
"	III	29	5	12	12	**86**	127
Danish	I	1	—	1	—		
"	II	1	—	1	—	**4**	16
"	III	2	—	1	1		
Dutch	I	3	2	1	—		
"	II	4	1	—	3	**8**	7
"	III	1	—	1	—		
Economic Geography ...	I	1,774	60	463	1,251		
" " ...	II	316	4	72	240	**2,190**	1,620
" " ...	III	100	—	19	81		
Economic & Social History	II	385	2	131	252		
" " "	III	143	—	51	92	**528**	390
Economics	II	1,122	96	393	633		
"	III	100	23	55	22	**1,222**	1,185
Elements of English Law ...	II	239	11	95	133	**239**	180
English (with Literature) ...	I	2,840	151	1,615	1,074		
" (" ") ...	II	674	20	365	289	**3,973**	3,919
" (" ") ...	III	459	24	283	152		
English for Foreigners ...	I	2,359	761	791	807		
" " " ...	II	2,057	336	1,047	674	**4,830**	3,757
" " " ...	III	414	52	183	179		
English Language	I	20,618	1,494	10,655	8,469		
" "	II	6,865	273	3,133	3,459	**27,951**	20,182
" "	III	468	2	81	385		
Esperanto	I	10	4	4	2		
"	II	13	7	5	1	**29**	56
"	III	6	1	5	—		
French	I	1,849	262	620	967		
"	II	329	42	95	192	**2,342**	1,880
"	III	164	16	67	81		
German	I	293	76	122	95		
"	II	114	30	45	39	**456**	478
"	III	49	8	25	16		

ORDINARY (SINGLE-SUBJECT) EXAMINATIONS

AUTUMN SERIES, 1957, AND EASTER, WHITSUN, AND SUMMER SERIES, 1958—*continued*

Subject	Stage	Papers worked	1st Class (or Passed with Credit in Stage I)	2nd Class (or Passed in Stage I)	Not Passed	Total number of papers worked in each subject 1958	1957
History	I	638	14	290	334	**638**	473
History of the British Empire	I	125	—	32	93		
" " "	II	211	7	92	112	**408**	282
" " "	III	72	3	29	40		
Income Tax Law & Practice	III	25	2	15	8	**25**	19
Italian	I	230	89	97	44		
"	II	63	26	29	8	**328**	315
"	III	35	5	25	5		
Law of Evidence and Civil Procedure	III	7	—	3	4	**7**	7
Law of Trusts	III	9	—	4	5	**9**	10
Norwegian	I	7	1	2	4		
"	II	2	—	2	—	**11**	17
"	III	2	—	1	1		
Public Administration ...	III	77	—	16	61	**77**	85
Real Property and Conveyancing	III	16	4	5	7	**16**	14
Russian	I	38	10	19	9		
"	II	11	2	5	4	**62**	70
"	III	13	3	3	7		
Secretarial Duties	II	741	46	346	349	**741**	574
Shipping Law and Practice	III	30	—	10	20	**30**	7
Spanish	I	289	79	102	108		
"	II	108	36	38	34	**448**	561
"	III	51	11	23	17		
Statistics	II	59	14	36	9	**67**	76
"	III	8	5	3	—		
Swedish	I	2	2	—	—		
"	II	2	—	1	1	**5**	1
"	III	1	—	—	1		
Typewriting	I	34,174	9,532	11,185	13,457		
"	II	18,890	1,408	6,605	10,877	**58,873**	52,459
"	III	5,809	298	1,765	3,746		
Welsh	I	24	5	15	4	**24**	19
	Stage	*Papers worked*	*Passed with Distinction*	*Passed*	*Not Passed*		
Shorthand-Typist's Certificate	II	3,481	91	2,136	1,254	**3,919**	3,424
" " "	III	438	2	223	213		
		Papers worked	*Passed with Credit*	*Passed*	*Not Passed*		
Shorthand:							
50 words per minute ...	...	13,428	1,742	2,916	8,770		
60 " " " ...	...	10,214	2,724	3,158	4,332		
		Papers worked		*Passed*	*Not Passed*	**50,848**	48,823
80 words per minute ...	...	15,911		10,284	5,627		
100 " " "	...	6,854		3,464	3,390		
120 " " "	...	3,915		1,285	2,630		
140 " " "	...	457		117	340		
150 " " "	...	46		13	33		
160 " " "	...	23		9	14		
					Totals	191,946	166,224

In addition, the results of 810 papers worked at oversea centres have not yet been received.

PRESTRESSED CONCRETE

Three Cantor Lectures

by

G. W. KIRKLAND, M.B.E., M.I.C.E., M.I.Struct.E.

I. AN INTRODUCTION TO PRESTRESSED CONCRETE

Monday, 14th April, 1958

The dictionary (*Chambers's Twentieth Century*) definition of concrete is, 'formed into one mass', and it must be supposed that my audience has a basic knowledge of concrete in this course of lectures. Whilst apologies are due to those expert and familiar with this material, the subject is expanded slightly for the benefit of those not so acquainted.

Concrete as we understand it to-day is a building material composed of varying proportions of cement, sand and aggregates, that is, gravel, crushed stone or other hard material. These ingredients are thoroughly mixed with water and while in a plastic state the mixture is placed into moulds or otherwise shaped either on or off the final site of its use. After the requisite curing time, that is, the period necessary for the completion of the chemical changes caused by the admixture of water to the cement, the finished concrete has a high compression strength. This may vary from 1,500 lb./sq. in. approximately to as high as 12,000 lb./sq. in., or even higher, depending on the quality of the ingredients, the proportioning of them and the compaction and final density of the finished product. A material capable of being easily moulded to shape and of high compression strength is of considerable value to builders.

Concrete has been with us a long time. Nature produces natural concrete in many of the sedimentary rocks, the cements in these cases being clay slurries and other materials washed down by water and deposited with the original sands and gravels denuded from the face of the earth by water. In their search to imitate nature, men produced their artificial rock in the form of concrete. The Romans made good concrete, burning clay to make their cement, and Roman cements are still used in different forms and for specific purposes to-day. The greatest advance, however, in concrete manufacture followed the discovery of Portland cement. Briefly, Portland cement is made from chalk and clay. These two are first reduced to a smooth puddle and are then dried. The action of heat on the residue produces a clinker which is carefully ground to a specific degree of fineness, and the result is the Portland cement which we use to-day.

It may be of interest that the term 'Portland' is not, as some suppose, due to cement originally being made in Portland, but to its resemblance, when set, to a good quality Portland stone.

Progress in the use of cement concrete has been considerable. Control of the various ingredients has been studied and has now reached the stage where it is

possible to design a concrete mix in the laboratory to a required strength and to be reasonably certain that concrete made to the specified mix on a building site will, within quite a small margin, have the crushing strength required of it.

Although concrete as described is of great value to builders, it has one drawback so far as engineers are concerned, and that is a weakness in tensile strength. To overcome this weakness, engineers place within the part of the concrete subjected to tensile forces another material having a high tensile value. This material, or reinforcement, is normally steel, usually in the form of rods, round, square, twisted or mechanically deformed. In a beam subjected to bending forces the upper part of the member tends to squeeze together, being in a state of compression, while the lower part tends to stretch, and it is in this area that the steel reinforcement is used to resist the tensile forces. (See upper three diagrams, Figure 1.)

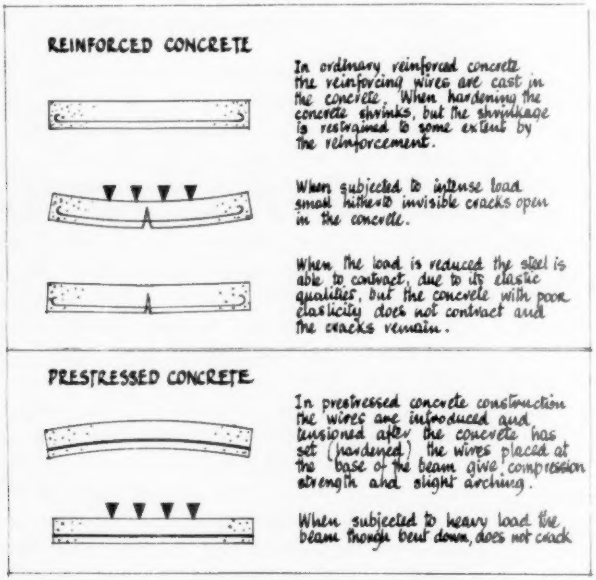


FIGURE 1. *Simple principles of bending in reinforced and prestressed concrete*

Steel is, however, elastic, and when subjected to tensile forces it stretches. As a result of this, small cracks of a hair-like nature develop in the surrounding concrete and, as I shall explain later, the overcoming of these cracks is one of the many advantages of prestressed concrete.

As improvements were made in obtaining high compression strengths in concrete, so has the strength in tension of reinforced concrete been improved. The first reinforced concrete had as its tension member, wrought iron, and with

the availability of mild steel bars the strength has increased over the years. By cold working of mild steel bars as much as 50 per cent increased strength has been obtained from the basic material, while the use of alloy steels has shown yet further increases in strength. The permitted tensile strengths of steel reinforcement have risen from 15,000 lb./sq. in., which I still remember using twenty-five years ago, to as much as 27,000 lb./sq. in. to-day.

The search for progress is a continuous one, and in 1928 M. Eugene Freyssinet perfected a system of prestressing concrete by tensioning high-tensile hard drawn steel wire. During the long years of the war M. Freyssinet was able to further improve and develop these ideas. The principle involved was to induce into the concrete an initial compression equal to or greater than the maximum tension to which the member would be subject when under load. As bending occurred, the tensile forces merely produced a reduction of the initial compression and, within the limit of the elastic range, the maximum stress in the wires would not exceed the initially induced prestress.

There are two forms of prestressed concrete in general use. These are pre-tensioned and post-tensioned concrete. In the case of pre-tensioned concrete the reinforcement is placed in a state of tension and concrete is placed around the reinforcement and allowed to harden. When the concrete is of sufficient strength the tension is released and is then absorbed completely in the concrete. In post-tensioned concrete the tension is induced in the reinforcement after the concrete has hardened and transferred externally by anchorages into the structure.

Figure 1 illustrates the principles of bending and the application of the external forces involved in prestressing. A much used simile of prestressed concrete which illustrates the principles involved is that of the book-case. If one takes from a book-shelf a number of volumes and holds them together simply by the volumes at each end, it will be found that due to the weight the line of books functions as a beam and those in the centre fall to the floor. By the exertion of considerable horizontal force applied to the two extreme books quite a number of books can be retained in position. In this case the whole of the forces are externally applied and the effort exerted by the arms is equivalent to the anchorage forces developed in post-tensioned concrete.

EARLY HISTORY

The first main production system in prestressed concrete was introduced by Hoyer, who in 1939 established a factory in Germany. The Hoyer system, which is an adaption of Freyssinet's work, utilizes very thin wires (about 2 mm. diameter) which are extended on a production bench of 200 to 400 ft. in length. The wires are held in position at the ends by passing through templates, and moulds are placed along the production bench to receive the concrete. In this way quite large numbers of units having similar cross-section and identical reinforcement can be produced.

Since the value of a prestressing bed bears a direct relationship to the time needed to cast and cure the concrete members made on it, it will be appreciated

that considerable work has been done to accelerate the time between the commencement of a casting operation and the production of a unit of sufficient strength to maintain the prestress during the final curing process. The use of rapid-hardening cements, the addition of accelerators to Portland cement, the use of high aluminous cement, steam curing and electrical heating have all been tried. In connection with the use of accelerators a word of caution may be necessary, for while nothing has been positively proved, it is believed that the use of the most well-known accelerator, calcium chloride, may contribute to failure of a member through stress corrosion.

A number of production plants in this country now produce a variety of products such as railway sleepers, fence posts, lighting standards, power transmission poles and compound parts for buildings such as barns and other farm structures, factories and workshops.

Prestressed concrete is not generally a competitor of post-tensioned concrete, but the two can frequently be used in association with one another.

M. Eugene Freyssinet is really the Father of prestressed concrete, and though the syndicate to which he belongs is over 50 years old, M. Freyssinet's fertile brain is even now devising new means and uses for the further development of prestressed concrete. Among his early work was the reconstruction of the Ocean Terminal at Le Havre, where prestressed concrete made possible work which would have been more difficult to execute by other means. The Ocean Terminal is a structure built on foundations almost 30 ft. in depth, and part was settling in 80 ft. of mud at the rate of 1 in. per month without signs of a reduction in the rate of settlement, while other parts of the structure had not moved. As a consequence, considerable distortion of the structure took place and collapse seemed imminent. By the application of the principles of prestressing M. Freyssinet restored the structure to stability in a remarkably short time and in such a way established himself as the world's foremost exponent of his own new technique.

Freyssinet was followed in 1940 by the late Professor Gustave Magnel, who devised another form of construction in this new medium. Professor Magnel's system will be dealt with at length later, but he contributed considerably to the work of his friend and rival, Freyssinet, and no appreciation of prestressed concrete would be complete without mention of his name.

Although Freyssinet's work on the Ocean Terminal at Le Havre was the first major prestressed concrete work abroad, it was followed very quickly by quite a number of applications. One such was prestressed concrete caissons at Brest; while numerous bridges on the Continent, which have been in existence almost ten years, show the progress which has been made.

In Britain we are a highly conservative race and, using an imported idea, we were naturally not so quick as our Continental friends in showing progress. When one realizes, however, that it took 40 years to establish mild steel as a natural development from the original wrought iron used in buildings and ships, we can pride ourselves on the progress of prestressed concrete in this country in an infinitely shorter time.

DEVELOPMENT

Factors which accelerated development. National economic stringency resulting from the immediate post-war economy has given prestressed concrete the largest boost in development derived by any material or idea other than war. In the same way that the principles of aerodynamics were mastered, and improvements in the performance of the internal combustion engine ensured rapid progress in flight during the First World War, so have the factors of building restrictions, tightened economy and short supply of steel accelerated the development and improvement of prestressed concrete.

After the war anyone needing to construct automatically sought alternatives to the materials in shortest supply, and steel was one of those materials most affected. When substitutes were found unsuitable, economies were achieved in the design and use of steel which a mere ten years earlier would have appeared revolutionary.

Prestressed concrete was used in such a way, and while grateful for the benefits we now enjoy as a result of the accelerated development, many engineers, including the author, regret that a number of structures conceived in other media were constructed in prestressed concrete using the original design conception. In the minds of many people prestressed concrete became regarded in consequence as a substitute. It was rather as though mild steel had arrived during an age of timber construction, and the structure had been built in the new material using precisely the same centres and spacings of the component parts as had been planned for in the timber structure.

As a substitute, prestressed concrete had proved its technical ability to do the job, but these methods of substitution did not show the medium to its economic advantage. Prestressed concrete must be designed so that it may appear at its best; and though not the universal panacea for all the problems of building and construction, it is in a large number of cases the most economical and satisfactory of the many alternatives.

A continued development of prestressed concrete was ensured when the Ministry of Works advocated its use and did much in publicizing the new structural medium. National economy necessitated reductions in the amount of steel used, and the new tool was here in the engineers' hands, but they had, in many cases, to be encouraged to use it. The Ministry of Works published a number of documents showing the advantages to be obtained from the use of prestressed concrete.

Another Government department deserving credit was the Ministry of Transport, which assisted considerably by making the grant of loan sanction for the construction of a large number of garages, etc., of which the country was in urgent need, dependent on steel economy, and giving not only its blessing but encouragement to prestressed concrete designs despite the many sceptics who existed at that time.

In 1949 the Prestressed Concrete Development Group was formed. This body of enthusiasts grew at an astonishing rate, and by means of visits to works under construction and to completed structures, both at home and abroad,

it was able to disseminate among its members some idea of the potential of this material. Engineers usually see at once the possibilties of a conventional material endowed with elastic properties, and the imagination of Designers was inspired by what they had seen. The Group became instrumental in finding out where shortages of prestressing steel and cement were imminent, and by representations to the Authorities it ensured that steps were taken to alleviate such situations, primarily in the interests of prestressed concrete development but generally to the advantage of the national economy as a whole.

A further major source of development came with the establishment of specialist firms which were prepared, some to design, others to design and construct, in prestressed concrete. The work was so obviously specialist that an immense new field of activity could be seen, and it is due to the pioneer efforts of many of these specialists that much of our work to-day is, to the converted at least, so normal in all respects. Other specialists undertook the supply of the various components, made up cables, sheaths and anchorages, and provided the tools, supervision and tuition to do the job.

The *Fédération Internationale de la Précontrainte* was founded at the first International Congress on prestressed concrete, which was held in London. It is an international organization set up to act as a permanent link between the various bodies concerned with the advancement of prestressing and to encourage the formation of such groups in all countries. It has been successful in its efforts to cover developments in many countries and to disseminate technical information, and it also promotes the exchange of scientific and technical problems. Two international congresses have been held since the formation of the Federation, the first in London, and the second in Amsterdam in 1955. The third conference is to be held in Berlin during May of this year.

Inspired no doubt with the success of these conferences, the University of California organized and held a successful World Conference on prestressed concrete in San Francisco last July, which was attended by more than 1,000 delegates from all parts of the world. The Prestressed Concrete Group sent a delegation from this country and their report has been given some publicity and will be further discussed at a special meeting in a few weeks time.

Research. The continued development of prestressed concrete was paralleled by the research activities of numerous bodies. The Ministry of Works established a research centre at the Thatched Barn, a disused road-house on the Barnet By-Pass, where work of considerable value was done in the development of elements and methods. Amongst other things the Ministry of Works produced a series of standardized beam profiles which was given a wide distribution.

Prestressed concrete lamp standards were produced and tested to destruction. The early results of much of their work was demonstrated to a large number of officials and other interested people during construction of a new office block in Whitehall Gardens, and the author was particularly impressed by the effect on the various visitors of a prestressed concrete plank (Figure 2) on which the visitors were invited to stand. Its ability to deflect very considerably and recover completely after both static and impact loading had a remarkable effect on the visitors.

FIGURE 2. *Prestressed concrete plank*

The Department of Scientific and Industrial Research at the Watford Building Research Station pursued the investigation of fatigue in prestressed concrete, and during 1956 published a report which demonstrated that the margin of security against fatigue failure was high. It is of interest to note, in the case of deformed or indented wires, that while resistance to fatigue failure was reduced, the margin remaining was adequate.

Other important research work was carried out by Professor R. H. Evans of the University of Leeds. His studies include bond strength in prestressed concrete and the influence of prestressing on the resistance to shear in beams. Professor Evans' work is quoted authoritatively in both these connections.

The Cement and Concrete Association at its research station in Buckinghamshire has carried out considerable research in prestressed concrete. Its laboratories at Wexham Springs are constructed in this medium, and provision has been made in the test floor for the future insertion of prestressing cables (Figure 3).

In conjunction with the Prestressed Concrete Development Group, the Cement and Concrete Association has sponsored further research elsewhere. Of particular interest is the research into fire resistance of prestressed concrete which has now been reported upon, while currently research is being carried out at Newcastle-upon-Tyne on stress corrosion, and a report on this will be published in due course.

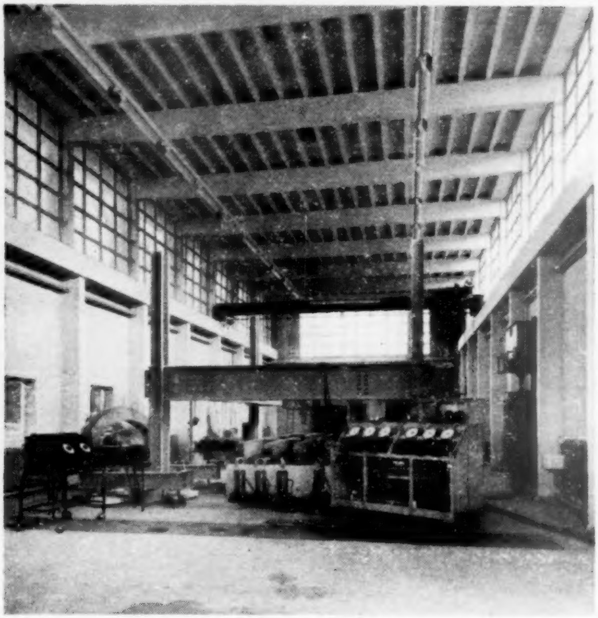


FIGURE 3. *Interior of the structures laboratory at Wexham Springs*

In the development of any new material problems invariably occur, and in the case of the Group, investigations, as distinct from pure research, have provided the answers to problems posed. Such problems have ranged from the provision of wire-cutter blades of an acceptable quality to the differential hogging of prestressed pre-cast concrete units.

Training. No longer is it necessary for engineers and others interested in prestressed concrete to pursue the rather tortuous course of acquiring knowledge of this medium by their own individual research and experiment. Educational facilities are provided by the Cement and Concrete Association courses which are held at the research station at Wexham Springs. These courses deal not only with theoretical and design aspects of prestressed concrete, but with the practical applications and the field use of this medium. Other facilities are available through extra-mural courses in prestressed concrete at universities and technical colleges. The University of London Faculty of Engineering, in the Department of Civil and Municipal Engineering, has run such courses successfully, and so has the University of Nottingham. The subject is so filled with the romance engendered by this material that there is never a shortage of lecturers on various general and specialist aspects of its use.

Examples of Works. A number of structures seem to me to indicate milestones of progress in the knowledge and handling of prestressed concrete, and though other people may conceive different milestones, the following selection will illustrate the progress of the material in its development stage.

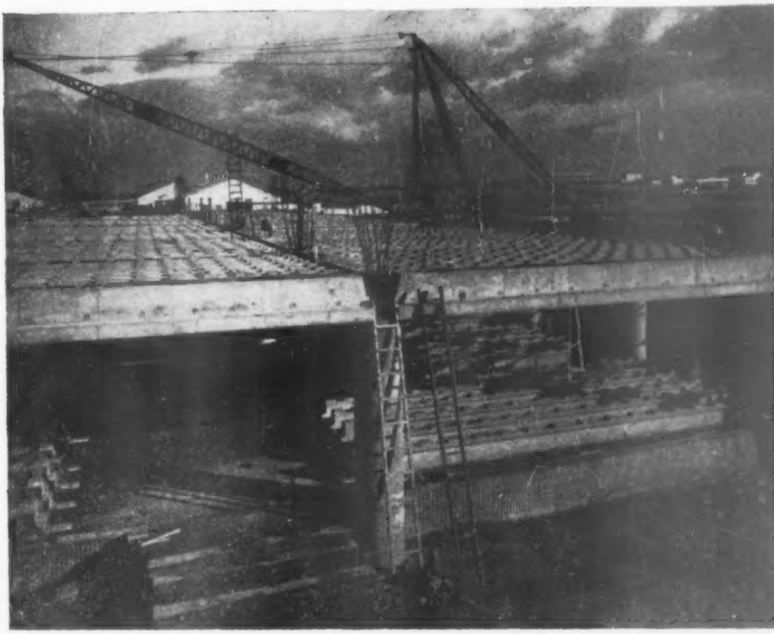
The author regards the Wigan Viaduct as a first milestone. This viaduct crosses the London-Midland-Scottish Railway between Wigan and Pemberton and was completed in 1947. It was the first structure built by the Railway Company in prestressed concrete. For some twenty-five years previously the Company had, where practicable, used precast reinforced concrete units for the reconstruction of bridges, and it was in consequence fully aware of this material's high resistance to corrosion and the consequent economies in maintenance. The Company had investigated the use of pre-cast prestressed units before the war, and during the early part of the war had manufactured a number of prestressed beams for emergency use by the Ministry of War Transport. The new bridge comprises four spans of a little under 30 ft., and the deck is formed of prestressed beams of 'I' section 32 in. deep, tied together by high-tensile steel tie rods to ensure that they act together under live load.

FIGURE 4. *Footbridge over the River Cherwell in the University Parks at Oxford, showing boat-landing in the foreground*

Figure 4 illustrates the Oxford Bridge. This structure, an arch footbridge over the River Cherwell, replaced a timber structure which was in danger of collapse. It is unique inasmuch as it was designed as a rigid arch, no temporary hinges being introduced at any stage. The bridge comprises twin arches tied at the centre and the ends. The bridge arches were post-tensioned with Freyssinet cables and anchorages, while the bridge deck was formed by open spaced pre-cast prestressed concrete planks. It is of interest to note that the boat landings, originally constructed of timber, which can be seen in the published photograph, showed considerable signs of distress due to scour at the time the bridge was under construction, and the engineer was asked to undertake remedial work during the period of the bridge contract. His solution was the use of prestressed pre-cast concrete planks similar to those used for the bridge deck. The planks were used as sheet piling and were driven into the river bed on the face of the boat landings. The void behind the planks was carefully filled with a dry concrete, displacing the water present.

FIGURE 5. *The Esbly Bridge over the River Marne in France*

The Worms Bridge, the first concrete bridge over the navigable part of the Rhine, is a spectacular example of prestressed concrete as used and developed in Germany. The bridge consists of three unequal spans determined by the foundations of an original structure, of approximately 300 ft. The bridge deck of 10-in. thick transversely prestressed concrete is carried by two box section prestressed girders of varying profile. The bridge was constructed as balanced cantilevers, the ends of which are connected at the centre of the spans with a joint to allow free temperature movement.



[By courtesy of The Scotsman

FIGURE 6. *H.M. Stationery Office store building at Sighthill, Edinburgh*

Figure 5 shows the Esbly Bridge over the River Marne in France. This bridge has a span of 242 ft. 9 in., and was completed in 1949. It is a two-hinged portal structure and the hinges embody a device for adjusting the end thrust by means of jacks. There are six portal girders in the width of the deck. The girders were assembled in halves and placed in position by erection masts sited on each side of the river. The deck slab is prestressed transversely. It must be conceded that despite the additional experience that has been gained since Esbly Bridge was built, there are few structures that can compete with it either from an engineering or—delightfully simple in line and form as it is—an aesthetic point of view.

Figure 6 in the field of buildings, the Sighthill Factory Building, is a new Stationery Office store constructed by the Ministry of Works at Edinburgh, and is another milestone of importance. The building was constructed with columns at 20 ft. by 30 ft. centres, and all the main beams and most of the secondary floor beams were pre-cast at the site, and post-tensioned by the Magnel-Blaton system, while the secondary roof beams were factory made and pre-tensioned.

Figure 7 shows an outstanding structure completed in 1950, the prestressed concrete elevated reservoirs at Orleans in France. As will be seen, the reservoirs are rectangular in shape and the structure below provides office accommodation. There are two separate reservoirs, each having a capacity of 1,600,000 gallons. A third section was about to be constructed when the photograph was taken. The dimensions of each unit are 148 ft. long by 108 ft. wide and 16 ft. high, each supported by 108 reinforced concrete columns. The whole of the floor, walls and roof are of prestressed concrete, post-tensioned by the Freyssinet system.

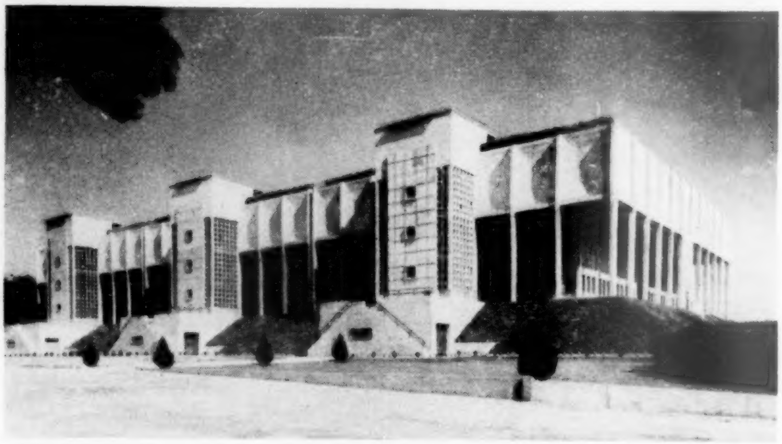


FIGURE 7. *Twin elevated concrete reservoirs at Orleans, France*

A prestressed concrete reservoir at Crawley New Town is 50 ft. in diameter and 21 ft. high, and has a capacity of 250,000 gallons. In this example, the concrete was prestressed by the Preload system which involves wrapping the walls with high-tensile steel wire under tension. This operation is carried out by means of a 'merry-go-round' device which rides on top of the concrete walls, and from which a cradle is suspended carrying and paying out the coil of wire. The tension is obtained by encircling the tank wall with a chain of robust construction to which the cradle is connected by gears, and sufficient frictional resistance to slipping is present to permit the necessary tension to be applied to the wire while paying out. On completion of the wrapping, the tensional wire is covered by concrete for protection.

The first prestressed concrete shell in Britain (Figure 8), that of Bournemouth Garage, consists of nine barrel vaults each of 150 ft. clear span. The overall dimensions of the building with no internal supports are 300 ft. by 150 ft. The

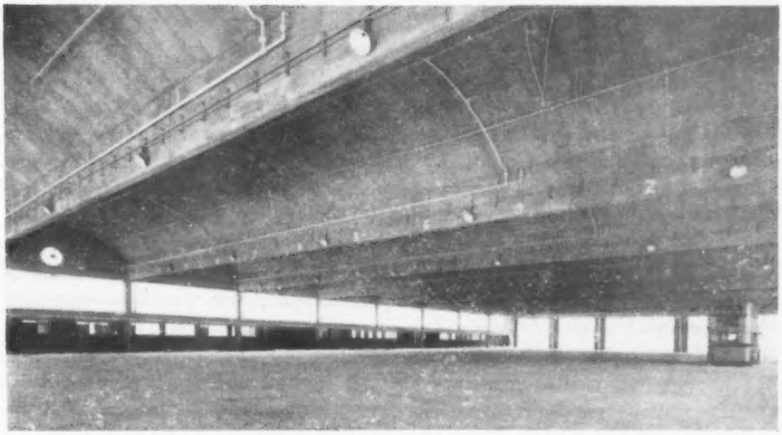


FIGURE 8. *Prestressed barrel-vault-roof garage for the Bournemouth Corporation Transport Department*

induced prestress in each of the internal edge beams in this structure is of the order of 400 tons. The garage, constructed for the Bournemouth Corporation Transport Department, houses 99 double-decker buses and electric trolley cars.

These few landmarks in the progress of prestressed concrete are indicative of the progress achieved in a mere decade, and serve to illustrate the impact of prestressed concrete in various types of construction work.

LECTURE II

Monday, 21st April, 1958

In the first lecture of this series I explained how external forces applied to cast concrete induced a compressive prestress, and a number of structures were quoted as milestones of progress and development M. Eugene Freyssinet and Professor Gustave Magnel were named as being the pioneers in this technique.

We are told that imitation is the sincerest form of flattery. The rapid progress and the introduction of new methods and systems imitating the results achieved by the pioneers, are indicative of the position which they, and the principles they developed, have now achieved.

The following are the systems I propose describing separately: the Freyssinet system; the Magnel-Blaton system; the Lee-McCall system; the Gifford-Udall C.C.L. system; the P.S.C. one-wire system; the Dywidag system, and the B.B.R.V. system.

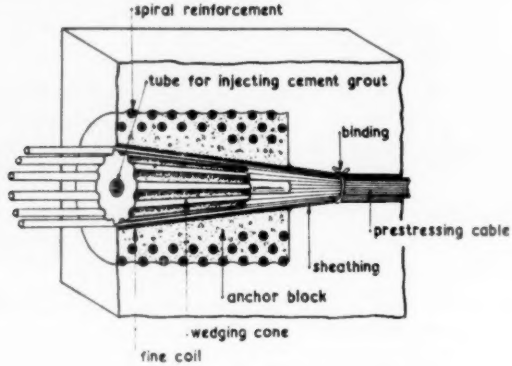


FIGURE 1. *The components of the Freyssinet system anchorage*

Figure 1 illustrates the various components of the Freyssinet system. First, the cable, which may be of 8, 10 or 12 wires. Wires may be of 0·2 in. diameter or 0·276 in. diameter. The wires are arranged in circular pattern around a central helix. The anchorage comprises two elements, a female and a male cone. These cones are factory-made of very high-grade concrete. The female cone, which is cast in the site concrete to be stressed, is heavily reinforced, like a gun barrel, by spiral coils of wire in order to prevent bursting under the effect of the anchorage load. The positioning of the female cone is of particular importance and care must be taken to ensure that it is positioned centrally and co-axially with the cable. The male cone is made around a central tube and is provided with the requisite number of accurately formed recesses in which each

one of the cable wires rests. The reinforcement of the male cone is somewhat more simple than that of the female cone, since under load the principal stress in the cone is compressive, and the reinforcement comprises a fine gauge wire mesh which is placed near the outside conical face.

In early prestressed work the cable was wrapped round with bituminized paper to prevent adhesion when cast in the concrete. Protection against this risk is now more readily achieved by sheathing the cable, either in thin sheet steel or iron ducting, plastic tubing or commercially produced corrugated paper or metal ducting. Alternatively a duct may be formed in the concrete and the cable threaded into the duct, being drawn through by a cable sock.

With the cable projecting through the female cone, the male cone is placed inside the protruding wires, which are arranged to nest one in each groove, and the cone is lightly hammered in. The jack, which is double-acting, is then placed in position, its head resting against the cast-in female cone, and each wire is individually secured by wedges to a collar on the jack. On the application of the jacking force all the wires are stretched simultaneously by the jack until the correct extension, which is measured, has been obtained, when by means of a tap provided, the jacking force is locked, and the opening of a further tap permits the already stored fluid pressure to act on an inner plunger which rams home the male cone, thus securing the wires. The jack is then released and the cable subsequently grouted through the tube in the centre of the male cone. The surplus ends of wire are cut off to complete the operation.

While the elements of the Magnel-Blaton system are not illustrated here, the cable, which is formed of wire of a type and size similar to that used for the Freyssinet cable, is of rectangular shape, containing from two to eighteen layers each of four wires. The wires are threaded through spacers or grills which are arranged at from 4 ft. to 10 ft. centres along the length of the cable. Again, the cable may be sheathed and cast in or threaded through a duct cast in the concrete. A feature of the Magnel-Blaton system is a special duct-former, made of specially prepared rubber of a size to suit the cable, being used with the necessary clearance to permit easy passage of the cable. The rubber core-former has a hole through its centre through which a steel rod or tube is threaded to give the former the rigidity necessary for it to be accurately positioned in the formwork.

After the concrete around the duct former has set, the centre core is withdrawn, and the rubber former is pulled out. Due to the elasticity of the rubber, a noticeable reduction in area occurs under quite a small amount of tension, and the former literally slithers out of the concrete, leaving a rectangular duct. A duct-clearing tool is inserted to clear any 'fins' or slight projections in the duct space. It is important that this operation be carried out while the concrete is green.

The Magnel-Blaton anchorage comprises four main elements: a distribution plate, 'sandwich' plates, shims and wedges. The distribution plate is of steel, rectangular in shape and perforated in the centre with a rectangular hole to permit the passage of the cable. The sandwich plates are of approximately 1-in. thick steel and have two trapezoidal slots on each of the upper and lower

faces, four slots per plate, each slot to contain two wires. The wedges grooved on the tapered edges, four per sandwich plate, fit one between each pair of wires.

The distribution plate is evenly bedded in cement mortar at the end of the member to be stressed, and the sandwich plates are placed between alternate vertical layers of wires. One pair of wires is placed in each of the trapezoidal slots and the wedges lightly inserted. A thin metal shim is placed between each sandwich plate, and the anchorage assembly completed.

Stressing is normally carried out from one end only, and wires are stressed in pairs. After checking the wires, the wedges at the end remote from the jack are hammered home under slight initial tension in the wires, following which the full tension is progressively developed through the jack until the correct extension of the wire, which is carefully measured, has been obtained, when the wedge at the jacking end is driven home. The jack is then released, secured to the adjacent pair of wires, and it follows the same sequence until the whole cable is stressed.

The Lee-Mc.Call is the next system described, since it differs from both the Freyssinet and Magnel systems in that a high-tensile alloy steel bar is used in place of the small diameter wires. The Lee-McCall system was developed in this country. The alloy steel rods used may be from $\frac{1}{2}$ to $1\frac{1}{8}$ inch in diameter, and may be used singly or in multiples. The anchorage is dependent on a special taper thread at each end of the rod through which the stress is transferred by degrees from the rod to the special nut which screws on to it. It is essential with this system that the length of concrete unit to be stressed be accurately determined between the anchorage faces, since only with the nut in its proper position on the taper thread can the full stressing force be developed. Limited tolerances are made possible by using washers as spacers. The elements of the Lee-Mc.Call system comprise the high-tensile alloy steel bar, taper-threaded at each end; the end anchor plates which are normally cast in the concrete unit together with a pressed steel grouting flange of trumpet shape (the latter being connected to a metal sheath); bearing washers to take up variations in length; and finally the special anchor nuts and jack adaptor.

A particularly useful feature of this system is the ease with which the prestress can be applied in stages and the equal facility with which repeated destressing and restressing can be carried out. It is further possible to restore losses in the original prestress which occur due to shrinkage of the concrete and creep in both concrete and steel, should this be necessary, provided that the grouting operation has not been carried out.

Lee-Mc.Call stressing is normally carried out from one end only. The remote anchorage, comprising bearing plate, washer and anchorage nut, is assembled and the nut screwed home. At the jacking end a similar set of components is assembled, but two washers are used to help reduce final friction when screwing the nut home on completion of the stressing operation. The nut at the anchorage end is screwed only finger tight, and on the projecting end of the thread a special adapter is screwed. The jack is placed in position and secured to the adapter

by means of a tapered cotter. One type of jack only is used with this system. It is of 45-ton capacity, and by use of separate adaptors can be used for any of the 'Macalloy' bar diameters available.

A system which has achieved some popularity is the Gifford-Udall-C.C.L. This system, like the Lee-Mc.Call, has been developed in this country, but unlike the former it uses wires and wire cables rather than rods. It can be used with a single wire or a cable of from 2 to 12 wires. Multi-wire cables are of circular section held together by metal spacers, and at the ends are opened out to individual wire anchorages. The end cable bearing is taken on a steel thrust plate through which the wires pass, each one of which is then inserted through a hole in the anchor plate, and the anchor plate is placed in contact with the thrust plate. The individual wire anchorages comprise a small steel cylindrical sleeve, the inner core of which is slightly conical, and one pair of tapered semi-circular wedges. The wire is threaded through the steel cylinder with the smaller opening towards the anchor plate. The wedges are placed one on each side of the wire and driven home into the sleeve. This securely locks the wire.

For the stressing operation, a special grip is placed over the wire after the anchor grip has been located, and the jack is slid into position over the special grip. When the necessary extension of the wire has been obtained, the conical half wedges are placed round the wire and hammered home. Successive wires are dealt with in the same way until the entire cable is stressed. The single wire jack is a small and compact piece of equipment.

Next, the P.S.C. one-wire system. This system also has gained some popularity in England. It is developed and operated by the Licensees in the United Kingdom of the Freyssinet system, and can be used with 1, 2, 4, 8, 10 and 12 wire anchorages. Like the Gifford-Udall-C.C.L. it has advantages where weight and size of the equipment are of importance, and apart from the rectangular cables and sheaths, the equipment available from the suppliers comprises the anchorage elements, (1) the guide, a flanged rectangular steel unit, trumpet-ended, which guides the wires into (2) the anchor block. The guide, which for the 4-wire anchorage is 3 in. long and a little less than 2½ in. square at the outer end over the flanges, is cast into the concrete element to be stressed. The anchor block, which is of cast steel, has tapered and slanting holes to guide the individual wires to the grip. A special Quick Release grip is a feature of the system, and is used in conjunction with (3) an internal bush which is embedded in the concrete with the flat surface exposed (for a single wire), or with an external bush for multi-wire cables. The system is undoubtedly a compact one so far as equipment is concerned.

Another system is the Dywidag system. In the first lecture the bridge at Worms was quoted as a milestone in prestressed concrete development. This system was used on that bridge. It is a German system and utilizes high-tensile steel bars, of 11.7 mm., 18.6 mm., and 26 mm. diameter (i.e., approximately $\frac{7}{16}$, $\frac{3}{4}$, and $1\frac{1}{32}$ in. diameter). As distinct from the British Lee-Mc.Call, C.C.L. system, the bars, while similarly threaded, are threaded by a rolling and not by cutting and taper thread process. In effect this gives a swaged end which is

threaded, eliminating the need for a high degree of accuracy so far as thread length is concerned.

The anchor units comprise an anchor plate rather more elaborate than those previously described, which is cast into the end of the concrete being stressed; a conical seating bush; and an anchorage nut.

The jack is applied to the threaded projecting end of the bar and the prestress applied. The jack is somewhat more complex than the other jacks described, but it must be noted that it contains in the single unit the nut-tightening spanner, the pressure gauge and extensionmeter.

Finally, I would describe the Swiss B.R.R.V. system, the initials being those of the names of the inventors and patentees. This system is a multi-wire system, cables being made up from 13 to 42 individual wires for standard stressing forces of 28, 56, 90 and 128 tons and diameters of ducts varying from $1\frac{3}{8}$ in. to $2\frac{3}{8}$ in. depending on the size of cable. Information is available of a still larger cable, capable of an initial force of 250 tons, in the course of development.

This system uses a 'nail head' ended wire. The wire is passed through a collar before the nail end is formed. (Figure 2.)

There are several types of anchorages available, which consist in general of an anchor head, a lock nut and bearing plate. An enlarged trumpet end is provided to the sheath enclosing the wires, which enables the wires to be located in the collar prior to the 'nail head' forming operation. A threaded draw bar which fits inside the 'nail head' receiving collar is used for tensioning, and a lock nut

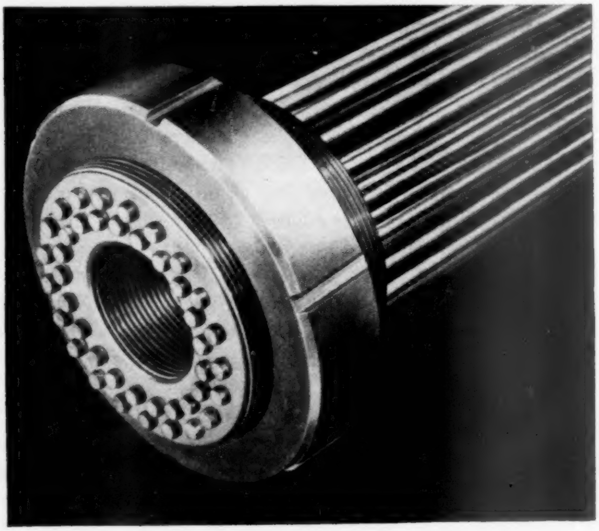


FIGURE 2. *The B.B.R.V. nail head assembly, showing the threaded collar into which the drawbar is screwed*

device similar in principle to both the Lee-Mc.Call and Dywidag systems ensures permanency of the anchorage.

Each of the seven systems I have described is used mainly for post-tensioning. Each system has certain points in common which will have been identified. All can be used in pre-formed ducts or cast in in sheathed cables. Anchorages depend on a wedge system, a nut and bolt system, or, in the last named, a nut and bolt combined with an expanded 'nail head' deformation of the wire. Similarly the wires, cables or rods can be used either in gentle curved form or straight. All systems can, and are generally advocated to be, grouted, although various circumstances can contribute to the rare advisability of an ungrouted system.

The grouting operation is one which, to be of any use at all, must be carried out with care. Considerable thought has been given to the grouting problem by the many users of prestressed concrete. The grout must be of high quality, should contain no surplus water and yet must be of such a consistency as to penetrate the whole cable length and fill the whole length without, or at least with a minimum of, voids. Pressure systems are naturally used. That the problems of effective grouting are of world-wide interest may be gathered from the fact that a paper was read at the San Francisco Conference on the subject, and claims of grouting at such pressures as are inconceivable here were made. These are being further investigated by correspondence with the States—a somewhat lengthy process!

The object of grouting is twofold: firstly, it is for the protection of the steel wire or rod against corrosion, either from condensate or atmosphere; and secondly, it is in order to obtain progressive stress transfer between the wires and the main concrete.

Since concrete continues to shrink slightly after casting and creep occurs in both the steel wires and the concrete after stressing, grout, if injected sufficiently early after the post-tensioning operation, can absorb certain stresses, transferring them to the main concrete.

Experiments have been carried out in grouting with expanding cements, but these have not been very successful, due to the difficulty in controlling the rate of expansion.

Unless a structure fails, or costly experiments are carried out on specially made test units, it is impossible to determine how successful the grouting operation has been although, for research work, X-rays and cobalt bomb photography have shown some results. An exceptional opportunity arose, however, to determine not only the efficacy of grouting but also the actual strength of a structure as compared with the design strength, when the prestressed concrete footbridge which had done yeoman service on the site of the Festival of Britain Exhibition was no longer required and was demolished. It is gratifying to know that despite imperfections in the grouting and the fact that this bridge could be regarded as a very early structure, failure took place after loading in excess of that anticipated by the designers as the ultimate strength.

It will have been noted that a figure of 45 tons has been quoted as the possible jacking force for a single operation, while a force of 4 tons may be required for

a single wire. In the unlikely event of an accident, a force of 4 tons to 45 tons, depending on the system in use at the time, could be released in a fraction of time over a distance depending on the extension of the rod, wire or cable used. The potential, converted and expressed in horse power, can be of such a magnitude as to demand some respect for the danger zone behind the jack. I beg you not to let this note of caution put you off. After all, who amongst us would willingly expose himself to the risk of standing below a 1-ton skip of concrete suspended 35 ft. in the air? Indeed, how many of us would voluntarily pass beneath a ladder?

At this point it might be as well to explain further the process of pre-tensioning as distinct from post-tensioning, since the main difference lies in the matter of uniformity of stress transfer throughout the length of a member. There are, however, additional claims in that the gripping of the strained wires by the concrete can be attributed to three separate and distinct factors. The first is bond strength, as in the case of normal reinforcement in concrete. Secondly, due to the difference in lateral expansion which occurs as a result of compression of the concrete and slight reduction of tension on release of the main tensioning force, an increase in bond strength is obtained; and thirdly, there is a cone action at the ends of the released wire due to the gradual build up of bond strength over the first few inches of wire length.

There are two principal pre-tensioning systems—the long line system for mass production work of similar elements, or the mould system in which the wires are tensioned against individual moulds. In this latter method, moulds must be purpose made and designed to resist the external forces involved in tensioning the wires.

As explained in the first lecture, pre-tensioning consists of a method of inducing an extension in the wires, the tension being maintained while wet concrete is placed in moulds around the wires, thoroughly compacted and allowed to harden. Figure 3 illustrates a modern long-line process prestressing plant. In the foreground can be seen one bed with two complete sets of wires positioned and awaiting the positioning of the moulds. The bed immediately to the rear shows a bundle of wires ready for positioning, while the next bed has just been emptied and the complete cycle will shortly begin. On the fourth bed moulds can be seen filled with concrete, and the wires between the individual units may be noted.

It will readily be appreciated that maximum efficiency of any pre-tensioning process is dependent on high early strength concrete, capable of sustaining the pre-tensioning force. Only when the concrete has sustained such a strength can the moulds be stripped and the pre-tensioning prepared for the next cycle of production.

Wire used for prestressing is high-tensile wire of such a diameter or shape as to enable the bond strength to be developed in as short a length as possible. Some manufacturers use crimped, twisted or otherwise mechanically deformed wire, but some loss of wire strength usually results. Wires are usually gripped

FIGURE 3. *A modern long-line prestressing plant*

at each end, and frequently one grip per wire is more convenient than multi-grip systems, and prestressing grips for long line production are designed for repeated use. Wires are passed through a perforated plate of robust dimension which serves as a template for wire location and an anchor plate at the same time.

The products of modern long-line prestressing plants are numerous. Standard units, which are everyday commodities to most of us, include railway sleepers, flooring units, lighting standards, transmission poles, and concrete piles. Amongst non-standard units there are beams designed and purpose-made for specific structures, beams with protruding stirrups to tie in with *in situ* work, bridge beams, elements for rooftrusses and frames, and numerous other structural components.

The use of prestressed concrete has resulted in overall improvements in concrete strengths, and the entire concrete industry has benefited accordingly.

A technique which has found much favour amongst engineers and others is that of fabricating a series of elements of handleable proportions in precast concrete, assembling them to make a whole member by jointing the units with high grade cement mortar, and post-tensioning the assembled units either in position where finally required or adjacent to the site, hoisting the complete unit into position.

In addition to the system mentioned specifically here, developments of these methods have taken place and new ideas have been tried out. I have mentioned oval-shaped and mechanically deformed and crimped wires, but a further development has been in the use of stranded cables. This method has been successfully used in Germany by Dr. Ing. Fritz Leonhardt. It comprises a system of multi-wire wire ropes which are taken round anchor blocks of reinforced concrete having a large radius. A gap is left between the anchor block and the structural concrete, and if necessary further gaps transversely to the direction of the stressing cable may be provided. Hydraulic jacks inserted into these gaps push the concrete elements apart, thus inducing compression in the concrete and tension in the steel. The spaces between the jacks are filled with high-grade concrete, closing the gap, and complete closure is effected after removal of the jack.

Considerable interest in the use of stranded cables has been engendered recently due to the high steel to concrete bond obtained by the twisted wire, and further uses of what is to all intents and purposes a conventional wire rope will undoubtedly follow.

In referring to the stranded cable, you will note I have made no reference to anchorages. The reason is that so-called 'dead' anchorages can and are frequently formed without recourse to any of the conventional commercial systems. Each of the various methods is based on obtaining progressive stress in each wire by either bond stress or bond stress and deformation. Anchorages of this type have been given names such as 'rats' tails', 'onions' and 'lemons'. The 'rat's tail' is an individual wire, coiled at its end and of such length that when embedded in the concrete the full wire strength is developed by both bond and deformation. The 'onion' is the name given to a return bend on a multi-wire cable. For a distance back from the bend, the sheathing is either omitted or stripped and the exposed wires are opened out to a bulbous shape reminiscent of an onion. The individual wires are usually tied to short lengths of wire to maintain the shape of the bulb during the concreting operation. The 'lemon' anchorage is the name given to an intermediate built-in anchorage formed by stripping the sheathing from a section of a straight length of multi-wire cable, and opening the wires at the centre of the exposed section to form a lemon-like profile. Each wire is similarly tied to short lengths of steel wire or rods to maintain the cable wires in position until they are concreted in.

These anchorages have proved most efficient in practice, and tests which were carried out in Germany with a multi-wire 'rat's tail' anchorage showed that the full working strength of a stranded cable could be developed in such a manner. When tested to destruction there was little to choose between wire and concrete, though ultimate failure must in honesty be attributed to failure of the concrete.

With all the commercial systems, as well as the various alternative methods devised, the critical zone in the concrete is that area immediately behind the anchorage, where the high stresses induced by maintaining the wire tensions are wholly absorbed, in the initial condition at least. The area immediately

behind the anchorage is subjected to a high bearing stress, while the plane immediately abutting the bearing transfer zone has to contend with particularly high shears. Some research into anchorage zone stresses has been carried out, using both stress-strain measurement and photo-elastic methods of analysis, and while anchorages rarely fail, they are at present usually over-designed. A useful field of research presents itself here, and is being pursued by certain authorities. At present, dispersal of anchorage forces is assumed to take place within a 45-degree conical section from the back of the anchorage and this zone is normally heavily reinforced with either coiled steel rods, or steel wire mesh mats. In order to satisfy themselves that these high stress zones are properly catered for, some engineers prefer to manufacture anchor blocks of pre-cast concrete under workshop rather than site conditions, and so ensure not only the ideal conditions for anchorage stress absorption, but also the accurate placing of the anchorage within the block in the case of the Freyssinet system, or a true and accurate bearing face for the bearing plate in other systems. The larger area of concrete which absorbs the stressing forces at the back of a prefabricated anchor block permits somewhat less rigorous specifications of the main concrete, and a more practical degree of site supervision than would otherwise be necessary.

Amongst the alternative methods of prestressing developed, there must be mentioned the two-direction prestress obtained with uni-directional cables, as in the case of the Orly Airfield. In this case the landing strip was anchored at each end by heavy concrete abutment foundations, and throughout its length was broken by triangular shaped sections which were formed with a small joint. Vertical rods were inserted into the joint and the transverse; Freyssinet prestressing cables were taken across the joint, being anchored at one end in the pavement slab and at the other in the wedge-shaped section. The application of the stressing force drew the wedge-shaped section into the pavement, thereby inducing a longitudinal prestress.

The author, faced with a similar problem on a continuous testing track, found his solution by arranging his cables in a diamond pattern. Anchoring the cables in, using 'lemon' type anchorages, and providing a gap to receive jacks on each side of the anchorage strip, he jacked the sections of pavement apart, thereby inducing tension in the cables and compression in the concrete. The jacking gaps were subsequently filled with concrete and the jacks removed. In the case of Orly, the major prestress was required transversely in order to disperse the impact of landing gear wheels, while in the case of the testing track, used for testing caterpillar-tracked tanks on a near impossible subsoil, the major prestress was required longitudinally.

It is of interest to note that in both these cases, the frictions which the designers had anticipated as a result of moving the concrete slab over the ground in order to obtain the prestress required, were not attained, and a smaller effort than that provided achieved the desired result.

Both these pavements have proved highly successful during periods of rigorous duty.

The case of the testing track is one of the few known to the author in which grouting was deliberately omitted. The cables were encased in plastic sheathing—due to shortages of steel nothing else was available, and at the corners of the diamond cable pattern high frictions were likely to develop during the stressing operation. This was borne out by strain readings, which showed a higher state of compression in the concrete abutting the anchorages than intermediately in the pavement. It was considered that by means of temperature changes and load variation on the slab itself the concrete stresses would even themselves out, as indeed proved to be the case before the finishing coat of asphatic concrete was applied.

No claim is made that prestressed concrete is the most economical answer to all pavement problems. Indeed, it only comes into its own when elasticity is of paramount importance, either by reason of poor subgrade, or loading intensity.

In this lecture, the problem has been to select, from the large volume of material available, data to cover the field; and of necessity, many interesting illustrations have had to be omitted.

In the final lecture will be shown some of the structures in which the various systems and methods have been employed

LECTURE III

Monday, 28th April, 1958

As I explained earlier, Freyssinet's success in using prestressing methods for remedial work at Le Havre established his system and proved the ability of prestressed concrete to perform a specific duty at the Ocean Terminal. In other countries many engineers have had their first introduction to prestressed concrete through the need to carry out remedial works due to one cause or another. It is certain that those who have learned to use prestressed concrete in this way have become amongst the greatest enthusiasts for the technique. In due course opportunities presented themselves to design in prestressed concrete, many engineers seizing these chances, and a number of remarkable structures have resulted. Publicity given to a successful undertaking inevitably leads to inquiries from other potential users, and it is indeed fortunate that the architectural profession has not been backward in exploring and making use of this medium of construction. Its adoption on many projects has frequently necessitated new methods of solution for some conventionally solved problems, and in building work, site progress has in many cases been considerably improved due to the necessity for prior investigation and progress planning to suit prestressed concrete techniques, as opposed to the acceptance of some timeworn conventional make-shift, a sin of which it is feared many have at some time been guilty. A typical example of these features is the need for the pre-planning of all services due to the undesirability of cutting away concrete which has been prestressed. On a fully prestressed floor it is no longer the best solution to cut a hole in the slab for a lighting conduit, with the consequential waste of effort required from the following trades to make it good. Instead, advanced planning allows for the fittings and services to be located in their proper places in a building during the carcase stage. Other improvements in construction methods have resulted, speeding construction time and cheapening overall costs.

In this, the final lecture, I propose to show you some of the various structures carried out in prestressed concrete, and to give a brief description of those I have selected.

My first example (Figure 1) is Langstone Bridge in Hampshire. This bridge connects Hayling Island with the mainland. The structure which preceded the new bridge was of timber and had been built in 1824. Due to decay, the original timber piles had been stiffened with brick and concrete casings to each bent. Progressive deterioration led to a reclassification of the safe load-carrying capacity, and in 1950 it was decided to build a new bridge rather than carry out extensive repairs to the old timber structure. Designs in structural steel, reinforced concrete and prestressed concrete were considered, and prestressed concrete in conjunction with reinforced concrete was selected, since it appeared to show most advantages in steel economy, speed of construction and low maintenance costs. The bridge is a multi-span structure of 29 spans

of 32 ft. with a double bent of 7 ft. span introduced either side of the five central spans. Though 16 -in. square reinforced concrete piles have been used, it has been stated that smaller piles of prestressed concrete would have been satisfactory, but aesthetics determined the size of the pile used. There are five piles to each bent, capped by a reinforced concrete beam.

FIGURE 1. *Langstone Bridge, Hampshire*

The bridge deck is formed of pre-cast post-tensioned beams of near rectangular section, the beam sides being slightly tapered to facilitate grouting. These beams are each post-tensioned with two Macalloy bars of $\frac{5}{8}$ in. diameter; one end of each slab is fixed to the capping beam by stainless steel dowels with felt collars, while the other end is bedded on bituminized felt. Parapet beams are of similar construction and are connected to the deck through reinforced concrete paving slabs which house ducts for the services crossing the bridge. Transverse post-tensioning was used to ensure that the deck beams acted as an isotropic slab. Sixteen cables of twelve 0.2 in. wires and Freyssinet anchorages were used for this purpose. The bridge, while strictly functional, is not unpleasing.

By way of contrast so far as dimension is concerned, the next illustration is the Lake Pontchartrain Bridge (Figure 2). This is the longest vehicular bridge in the world. It is sited in the New Orleans area of Louisiana, U.S.A., and is entirely a water crossing, constructed at a cost of $30 million in order to achieve a mileage saving of some 150 miles, the alternative route bordering the Lake. It was necessitated by the industrial development of New Orleans, requiring dormitory facilities for an increasing labour force. It is remarkable in that the contractors erected a lakeside pre-tensioning plant at a cost of some $6 million to produce the material required in the bridge. This, I feel, is a point to be seriously borne in mind when comparisons in either direction are made between the United States and Britain. Our geographical location is such that a similar project

FIGURE 2. *Twenty-four-mile long prestressed concrete bridge over Lake Pontchartrain, near New Orleans, U.S.A.*

would be inconceivable here, but should a prestressed Channel Tunnel ever become a possibility, it is certain that our engineers would handle the problem in a similar manner, with site production. The bridge involved the manufacture of almost 5,000 prestressed concrete cylinder piles of an average length of 88 ft. Pile segments 16 ft. long were prefabricated by spinning, incorporating twelve longitudinal cores. Segments were connected together with high strength mortar joints and post-tensioned, and were taken from the stockpile by barge to the site, where they were positioned by a template and driven home. The capping beams are reinforced concrete, precast but not prestressed, and they incorporate a projecting cage of reinforcement located within the core of each pile and cast in. The bridge deck, however, is remarkable. Apart from the centre bascule spans, it comprises 2,235 spans of 56 ft. four-lane traffic way, plus pavements and curbs. Each span, comprising seven longitudinal beams and finished surfaced road slab, was erected on the prepared supports as a completed entity ex the lakeside works. Each deck element functions independently and is separated from its neighbour by a 2-in. wide gap. It will be appreciated that the plant element must have figured largely in the final cost. It is also of interest to note that the methods of erection decided upon were influenced by the considerable amount of fog and storms experienced in the area. This could be a 'sales point' when we English talk to the American who thinks of us as

people from a land of fogs! We are told that the concrete strength specified at stress transfer was 3,000 lb. per square inch (on 6 in. diameter cylinders) as compared with our usual 4,000 lb. (on 6 in. square test cubes). It will be agreed that this is a remarkable bridge. It was completed in nineteen months, four months ahead of schedule.

By way of a change, the bridge connecting Eel Pie Island in the Thames with the Twickenham bank of the river is deserving of description. This bridge has a centre span of 84 ft. with two spans, one 34 ft. and the other 10 ft. 2 in., on one side, and a single span of 42 ft. on the other. It is 6 ft. wide, and has a considerable camber which was determined by the navigational requirements. In order to avoid obstruction of the waterway, two post-tensioned beams made up from factory pre-cast 'Tee' shaped elements post-tensioned through diaphragms form the main structure. The table of the 'Tee' beams forms the deck, and the elements are post-tensioned with Gifford-Udall cables 160 ft. long, stressed without difficulty, despite the curvature, from both ends. While the total construction time was three months, the navigable channel was restricted for only ten days.

A double-decker, combined railway and conveyor bridge at Calverton, Nottinghamshire is another valuable example. This bridge was constructed for the East Midlands Division of the National Coal Board, and since the Local Authority would not permit a separate crossing of the highway, the coal conveyor was housed in the space between the bridge deck and soffit. The minimum headroom requirement of 5 ft. for the conveyors was made possible by the use of prestressed concrete and its ability to perform-load carrying functions in minimum depth. The two main girders were pre-cast in convenient lengths, and post-tensioned by the Freyssinet system, which was in fact used throughout.

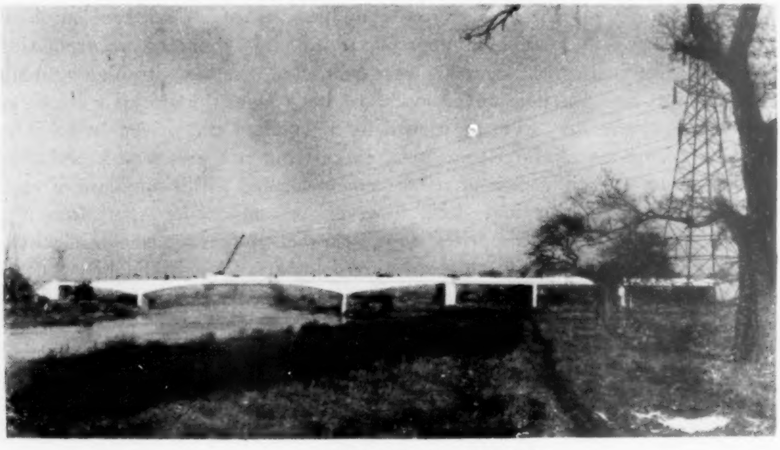


FIGURE 3. *Clifton Bridge, Nottingham*

The two conveyors are carried on a lower deck of 7-in. deep pre-tensioned pre-cast hollow beams which span between the bottom flanges of the side girders, while the railway, a single line track designed for 104 tons, is carried by a 9-in. thick deck of prestressed units. Both upper and lower decks are transversely post-tensioned and the upper deck is dowelled to the main girders.

The final example of prestressed concrete bridges has a personal connection, since the author's firm were the consulting engineers. The Clifton Bridge at Nottingham (Figure 3) is designed as two balanced centilevers with a suspended central span of 100 ft. The cantilevers are 87 ft. 6 in., and are tailed down by 125 ft. end spans. Three 90 ft. span viaducts form the south approach, while the northern approach is on earth-filled embankments perforated by three 40 ft. span openings. Apart from the three northern spans the prestressing system used throughout is the Magnel-Blaton system, while the Lee-Mc.Call system was used for the three northern spans. The bridge, which is 1½ miles upstream of Trent Bridge, crosses the river at a skew of 24°. The centre 100 ft. span is formed of post-tensioned pre-cast beams, while the two cantilever spans are cast *in situ* and post-tensioned. The concrete faces of the arches are cast with vertical flutings to give a textured appearance to the finish.

From bridges, buildings appear a natural follow through, and the first example of these described is the new printing works at Debden, Essex (Figure 4), constructed for the Bank of England. The main building is some 800 ft. long by approximately 300 ft. wide and is mostly two-storey construction. The main

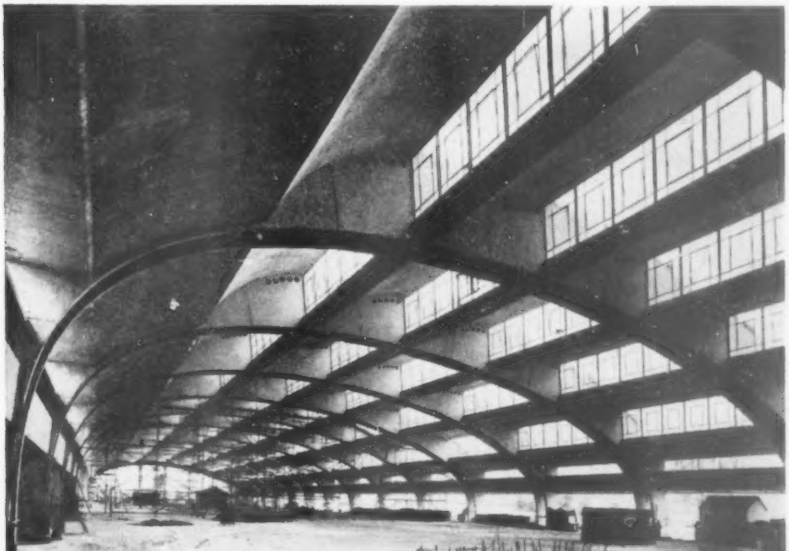


FIGURE 4. *Bank of England printing works at Debden, Essex*

production hall comprises 22 identical bays of arched beam and shell roof with vertical north light glazing. The arches are formed of pre-cast concrete elements weighing about 5 tons each, these being assembled and post-tensioned, while the shell roofs connecting the arches were cast *in situ*. A smaller production hall and a number of ancillary structures comprise the whole project, some of which are prestressed concrete while other parts are of reinforced concrete. The main hall is, however, the most outstanding feature.

Arch structures form a most suitable type of building for the economic use of prestressed concrete. A typical example of such a building is the Sulphate of Ammonia Store and Bagging House for the South Eastern Gas Board at Phoenix Wharf, Greenwich. The dimensions of the completed store are 168 ft. long by 96 ft. wide, while the Bagging House is 108 ft. by 60 ft. long. The store has sloping wing buttressed retaining walls 17 ft. 6 in. high, which were cast *in situ*. The buttresses each support pre-cast concrete three pinned arch ribs which were post-tensioned, using the Lee-Mc.Call system. The arch ribs are 12 in. wide and vary in section from 1 ft. 9 in. to 2 ft. 9 in. Due to the length of the ribs and the practical limits of the Macalloy bays, couplers were used to join two lengths of bar. The cladding is formed of pre-cast pre-tensioned concrete planks manufactured by the individual mould method and placed between the ribs. At the apex of the ribs two special crown slabs span from arch to arch resting on ledges provided, and are post-tensioned from the outside of the supporting

FIGURE 5. *Cigarette factory at Lisnafillan, Northern Ireland*

rib with Gifford-Udall-C.C.L. cables and anchorages. The cables are consequently lapped across each rib and provide a horizontal tie between the individual arches. It is of interest to note that this is one of many examples where more than one system of prestressing is used in the same structure.

Figure 5 shows part of the roof of a cigarette factory constructed at Lisnafillan, Northern Ireland. The building comprises two production halls of identical construction, 105 ft. wide by 600 ft. long and 900 ft. long respectively. There are no internal columns. Hollow pre-cast beams span the 105 ft. width at 30 ft. centres and are connected by pre-cast north light shells. The beam units are 9 ft. deep, 4 ft. wide, and 12 ft. 8 in. long. They were positioned on scaffolding with diaphragms and then post-tensioned by the Gifford-Udall-C.C.L. system. Shell elements comprising a gutter beam and curved slab elements were pre-cast on site and hoisted into position. They were connected to the main beams with *in situ* concrete. The illustration shows the chase in the beam elements from which reinforcement projects to connect to the shell section. This and the

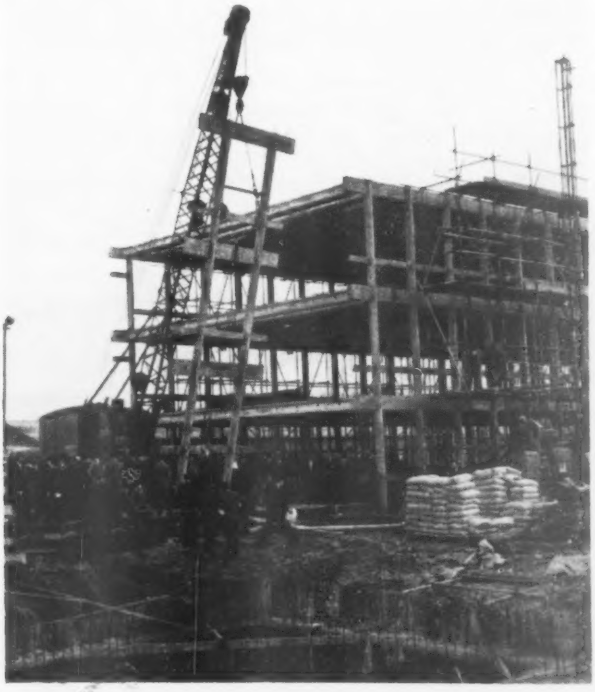


FIGURE 6. *Administrative offices for the Shell Refining Marketing Co. Ltd. at Shell Haven*

preceding two buildings are of a specialized nature to suit processes, plant and materials, and lest it might be thought that the application of prestressed concrete in building is restricted to unconventional structures, the next example is a more conventional office structure erected for purposes of administration at Shell Haven for the Shell Refining Marketing Co. Ltd. (Figure 6). This building is three storeys high, 294 ft. long and 43 ft. wide. There are no internal columns in the building; thus complete freedom for internal planning is possible. The wall frames comprise pre-cast reinforced concrete columns at 6 ft. 8 in. centres cast in pairs, complete with three cill beams and three edge beams, each of which projects half a bay beyond the column, and these are connected to similar projections on the adjoining bay. Reinforcement projects from the edge beams to tie into the *in situ* part of the floor slab. The floors are supported on pre-tensioned concrete beams of inverted 'Tee' section placed at 3 ft. 4 in. centres, and permanent shuttering to support the *in situ* floor concrete is of corrugated asbestos sheets resting on wood strips which are bolted to the beams. The last of the building examples is an interesting structure for Messrs. R. F. Seward at Southampton (Figure 7). The building houses a showroom and garage at ground level and a factory at first floor level.

The ground floor in which the garage is situated is divided longitudinally by two rows of columns giving three bays of 47 ft., 62 ft. 8 in. and 47 ft. Some of the

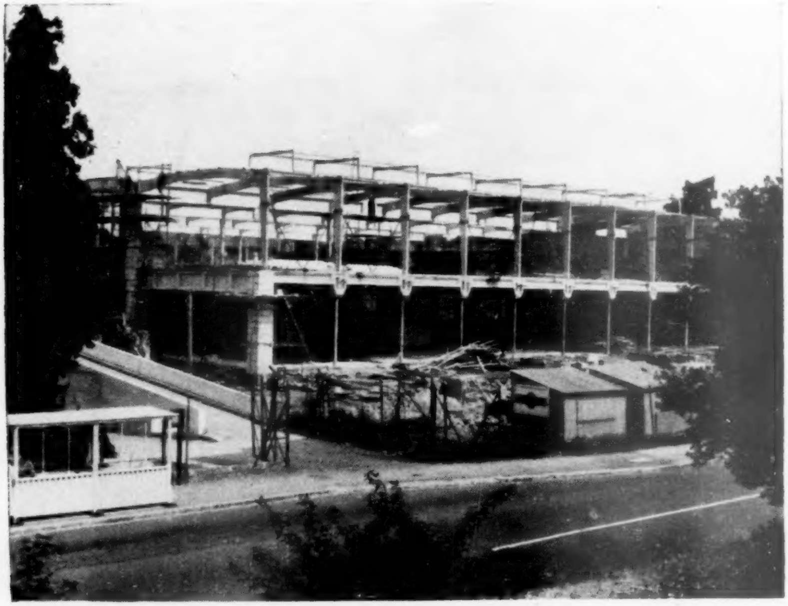


FIGURE 7. *Garage for Messrs. Seward Ltd. at Southampton*

columns are pre-cast concrete. Those carrying the main first-floor beams are cast *in situ*.

Pre-cast prestressed 'I' section main beams, 3 ft. 10½ in. deep overall, span the three bays in three sections, cantilevering beyond the internal columns a distance of 5 ft., leaving a central span of 52 ft. 8 in. which is supported on the cantilever ends of the adjoining beams. At the points of suspension bearing is taken on 3-in. diameter mild steel rollers sited between the halved ends of the beams, and the prestressing cables are arranged to resist the bending and the shear stress in the halving.

The whole of the prestressed work in this structure is by the Gifford-Udall-C.C.L. system, which was post-tensioned and cast in pre-formed ducts in the concrete. The mortar joints between the various segments were corked with stiff cement mortar. The beams were assembled and jointed on the ground floor slab and lifted to their positions by erection masts. Only part of the post-tensioning operation was carried out before the beams were lifted, and the remaining cables were tensioned after the secondary beams of the floor panels had been positioned. In the cantilevered beams the additional cables were stressed from outside the building.

The tops of the main beams were castellated to ensure bond with the floor slab, while the secondary beams were transversely ridge-tamped for the same reason. The floor slab is of composite construction, having pre-cast soffit panels 3 in. in thickness spanning between the secondary beams and covered with 2-in. thick *in situ* concrete. The main roof beams are of 'I 'section 3 ft. 4 in. deep and are precast in 15 ft. lengths. They form the same total length as those of the first floor level, but the cantilever has been increased and the length of the central portion reduced to 41 ft. 2 in. Diaphragms cantilevering 5 ft. 9 in. on each side of the main beams, between each of the main beam elements, form the haunch section of the pre-cast secondary beams. The main beam lengths were assembled on the finished floor slab beneath their final positions and partially post-tensioned before hoisting into position. The remainder of the post-tensioning was carried out as the additional loads were added. This building is an excellent example of the combination of pre-casting and post-tensioning.

Due to the high density of prestressed concrete and the continuous compression to which it is subjected, it becomes an ideal medium for water-retaining structures. One of the most interesting examples in the author's opinion is that of the prestressed concrete dam at Allt-Na-Lairige in Scotland. The reservoir formed by the dam will impound 800 million gallons of water. The dam is 1,360 ft. long and has a maximum height of 73 ft. Figure 8 shows the dam in course of construction, and the relatively slender section may be compared with the more usual mass concrete dam section: the advantages of prestressed become immediately apparent.

Vertical chases were formed in the concrete and tied to an anchored bulb of concrete some distance into the rock strata. The Lee-Mc.Call system of prestressing was used throughout.

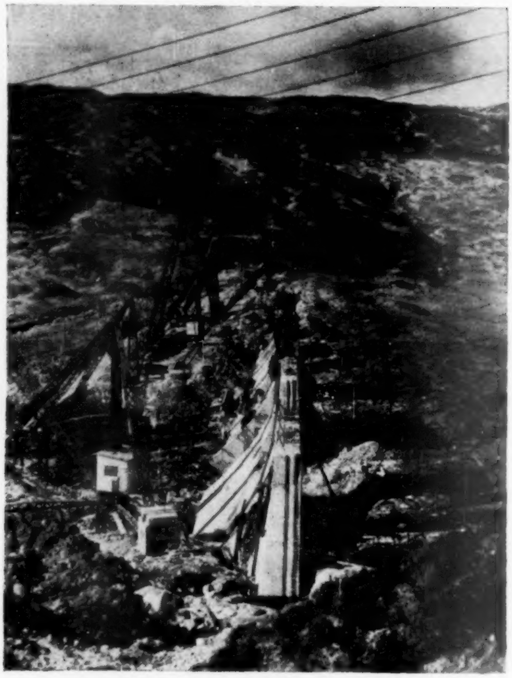


FIGURE 8. *Allt-Na-Lairige Dam, Scotland*

A number of prestressed concrete tanks have been constructed. Five tanks completed at the Palliser Works of the British Periclase Co., for the Ministry of Supply, are a further example. Two of them, with a capacity of 2 million gallons each, are claimed to be the first to be constructed in this country in prestressed concrete. The Magnel-Blaton system of prestressing was employed. The walls of the tanks vary from $11\frac{1}{2}$ in. at the base to 6 in. thick at the top, being stepped back in eight equal steps approximately 4 ft. apart. The prestressing wires were then placed around the tanks and tensioned. A final application of a cement render was then made to protect the tensioning wires.

Another example is a prestressed concrete tank at Paisley constructed for the Town Council and with a capacity of 2 million gallons. It makes a useful comparison with the preceding tank in that the circumferential stressing was carried out by means of 'Pre-Load System' in which a 'merry-go-round' mechanism described earlier pays out the wire in tension on the face of the concrete. A chain placed around the tank ensures purchase of the tensioning device. It is claimed that by this method the undesirable surface friction which occurs during the circumferential prestressing can be avoided. With this system the possibility

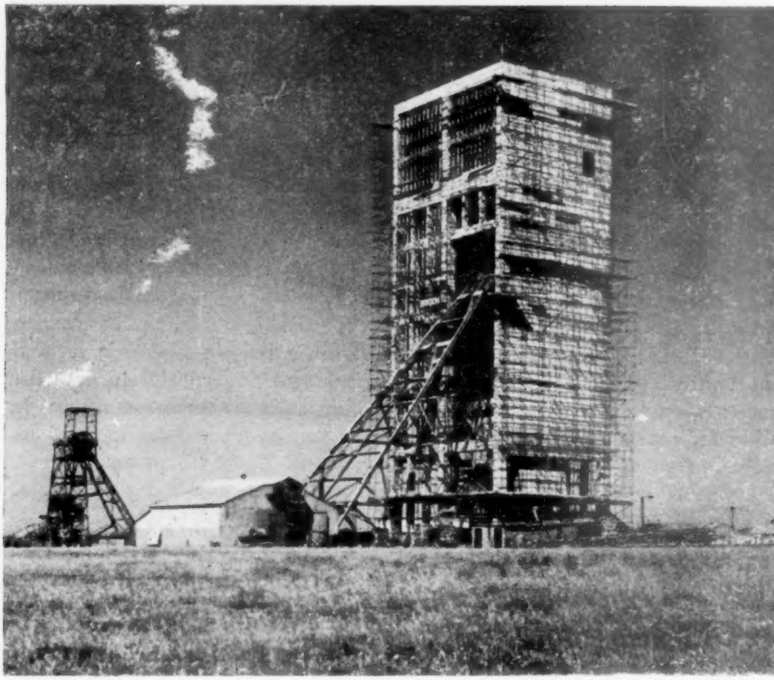
of a breakage of the wire during prestressing is overcome by the application of a permanent clamp about every four turns of the wire. If any break occurs, only the rewinding of a small portion of the tank would occur. The tank is covered by a dome roof, and to overcome the tension caused in the tank wall by the action of the dome, vertical prestressing has been introduced, provided by ⅝ in. diameter MacAlloy bars at 2 ft. centres, post-tensioned by the Lee-Mc.Call system.

A final example of tanks is at Drakelow Power Station for the British Electrical Authority. This is prestressed by the Freyssinet system. The tank is used in connection with the supply of water for the boilers, which is drawn from deep artesian wells and has to be softened before using. There are two tanks of identical size, forming part of the water-softening plant, and each tank is 160 ft. in diameter and 30 ft. high. The walls were cast in twelve segments and tensioned by separate lengths of cables, the ends of which overlap in the thickened buttress section. The buttress occurs on both sides of the tank wall projecting from both the inner and outer face of the wall by 6 in. The cables are anchored alternately inside and outside the tank face. There is no vertical prestressing in this tank and each segment of wall was cast in one operation. There are, in consequence, no horizontal construction joints, the only construction joints being the vertical ones between the segments.

A further illustration introduces yet another field of engineering: prestressed concrete foundations support the Television Tower constructed at Stuttgart, Germany. The overall height of this tower is 695 ft. from the ground to the top of the antenna. The steel antenna is 167 ft. 4 in. in height. Some conception of the total height of the structure may be gathered from comparison of these figures.

While the tower itself has been constructed in normal reinforced concrete, the foundation is prestressed and comprises two frustum-shaped shells of opposite inclinations which are joined together below the shaft at ground level and which vary in thickness from 11 in. to 22 in. Two horizontal ties are provided, one in the upper part and one in the lower part, the first linking the apexes of the cones, and the lower linking the base of the cones. The lower tie forms part of the foundation proper, and this is the portion that is prestressed. Although full details of this rather delightful continental structure are not available, it is believed that it was prestressed with stranded cables as frequently used by Dr. Leonhardt, who was in fact its designer.

As a final example, what is believed to be one of the most outstanding prestressed concrete structures in the United Kingdom is shown in Figure 9. This illustration shows the state of the work last June, which was approximately the time when the author was privileged, together with a number of other engineers, to make a visit. The National Coal Board, in order to exploit low level resources of coal by what is known as 'horizon mining' methods, developed this form of head gear. The raking legs which can be seen in the photograph are part of the shaft-sinking mechanism and form no part of the final head frame, which was constructed entirely over the shaft-sinking operations.



[By courtesy of the National Coal Board

FIGURE 9. *Killoch Colliery headgear, Scotland*

In order to ensure minimum interference with the important task of sinking the pit, the whole of the lower part of the structure is constructed of pre-cast units separated by a mortar joint. A head frame similar to this had previously been designed by the same engineers for Seafield Colliery, Fife, and the construction problems which were encountered there were completely solved in the design of this head frame at Killoch. The beams in the structure are pre-cast in one length and not as elements. The structure was arranged to be self-supporting at all stages, and the column units were assembled to some 18 ft. in height and progressively post-tensioned, using the Lee-Mc.Call system, until they had obtained the level at which the transverse members were connected. The beams were pre-cast in one length so that they would be self-supporting and not necessitate the use of scaffolding to carry the construction loads. The method of erection of these rather heavy members was to support them temporarily on steel brackets which were clamped to the columns, and the joints were then made and prestressed by cables inserted through the columns. The Freyssinet system has also been used on this structure.

Despite the fact that mortar joints between the column segments were 1 in. in

thickness, the column lengths were particularly accurate. Where *in situ* concrete work commenced, lengths of 24 in. by $7\frac{1}{2}$ in. rolled steel joists were secured to the prestressed concrete columns by short lengths of Lee-McCall bars, which were then tensioned, and the single pin joint exerted sufficient pressure to resist rotation. The construction of the upper part of the tower was by normal reinforced concrete, but the general technique was one which struck the author as outstanding.

This item concludes the examples, but it will be appreciated that in so wide a field descriptions are limited to the photogenic, and—so far as items not illustrated are concerned—to those either spectacular in dimension or having some unusual feature capable of reasonable description.

A vast amount of prestressed concrete work has been carried out in flooring to multi-storey blocks of offices and flats, farm buildings, housing estates, and the like.

It was stated in a paper presented to the Parliamentary and Scientific Committee last year that at the present rate of consumption the natural gravel aggregate resources of this country will be fully consumed within the next twenty years. The amount of concrete work in hand and likely to proceed during this period will probably be at a rate in excess of the current rate of consumption, so that as the material becomes less readily available its price is sure to increase, and engineers will be obliged to resort to man-made aggregates. A number of artificial aggregates will shortly be available, and these, some designed on expanded and burnt clays, some on clinker etc., will be lighter in weight than the conventional aggregate. The future needs of industry would seem to indicate the development of future artificial aggregates having particularly high strength values. Some experiments have been carried out in this country in the use of light-weight aggregates, but at the moment local authorities are reluctant to give consent to the construction of prestressed concrete work using these materials. Improvements which we are bound to see in the near future should overcome the difficulties now being placed in the way of their use.

Another material which may contribute considerably to the future of prestressed concrete is the introduction of high-tensile glass fibre to take the place of steel. Up to now all efforts using glass as normal reinforcement have failed, due to the low modulus of elasticity in glass as compared with that of steel. The modulus of glass is only twice that of the concrete and as a consequence very little tensile stress will be transmitted to the concrete by the glass reinforcement.

In prestressed concrete conditions are different. The low elasticity of glass fibre becomes of advantage, since the losses of prestress due to creep, shrinkage, elastic strain and temperature changes in the concrete which are generally taken as from 15 to 20 per cent., in prestressed concrete work would be reduced to a very low figure. Glass fibre is known to have a particularly high strength, and though the values vary they are quoted in the upper limits as between 3 and 4 times 10^6.

Glass products commercially available do not attain these high tensile strengths,

but fibres used for the reinforcement of plastics produce an average strength of 270,000 lb./sq. in., while laboratory results on freshly formed and carefully protected fibres have attained strengths of from 600,000 to 750,000 lb./sq. in. The ultimate tensile strength of a commercial product ranges between 150,000 and 400,000 lb./sq. in. It will be seen from these figures that the potential of glass as a prestressing medium is very considerable, but much further research must be carried out before it becomes a practical possibility. Anchorages must be devised and no doubt in not too long a time new resources will be made available.

The future of prestressed concrete holds even greater prospects in store for the engineer with imagination and a 'feeling' for this remarkable material. Amongst the many applications of it in the years to come can be quoted the London Air Rail, the monorail to serve London Airport from central London, which is a practical possibility thanks to prestressed concrete. Another example is the development of urban motorways, those essential new arteries for our country, without which our industries will decay from 'arterial sclerosis'. Many other future applications will become apparent.

In connection with the air rail, the scheme placed before the authorities envisages the use of a prestressed concrete beam of 4 ft. 6 in. in depth and 2 ft. wide. These dimensions are determined by the mechanical requirements of the coach. In reinforced concrete, taking advantage of all economies possible in weight, the maximum span which its section could satisfactorily attain would be a mere 40 ft. By the use of prestressed concrete, however, spans of up to 100 ft. are immediately possible.

It has been proposed that the running rail would be formed of pre-cast elements of 10 ft. in length joined into a whole by caulked mortar joints and post-tensioned in multiples of 10 ft. with purpose-made sections to give the exact centres of supports where they varied, to suit obstacles which will inevitably occur over the selected route. The advantage of this proposal is that the very large number of units could be made off-site by the various manufacturers of pre-cast products to a standard set of moulds, and by virtue of a more reasonable weight as compared with that of the complete 100 ft. girder, they could readily be stock-piled at intervals along the side of the proposed track, subsequently being moved to alongside the final position they would be required to occupy immediately prior to post-tensioning.

One of the major expenses of the air rail lies in the number of supports required and the foundations for them, and it will be readily appreciated that by increasing the spans to the maximum economic limit the consequent reduction in the number of supports shows big advantages in costs.

No doubt other monorails will be developed in the course of time, since this form of transportation, making use of air space over crowded land masses, would appear to be one of the few possible solutions to the transport problems of to-day.

Living as we do in a highly concentrated community, made so by reason of our island and the way it has developed, we are faced with problems somewhat different from those of the larger countries, where the proportion of agricultural

land per head of the population is so much higher. Britain, it will be remembered, was an agricultural community until the days of the Industrial Revolution, when the need for transportation of raw materials and finished products produced the incentive which resulted in the railways and the need for their expansion. Having been built in the earlier part of this machine era, the railways were able to select the best routes for their development before the growth of the large mass of suburban housing, dormitory areas and industrial areas which now surround our towns and cities.

The railways serving all major towns in the country follow a route which runs, willy-nilly, through heavily built-up areas. These grew up as a result of the railway facilities in their immediate environs, but subsequently they surrounded the tracks because other space was no longer available.

We all read of rush-hour and peak-load traffic, and the future possibility of building overhead roadways above existing railway tracks is therefore particularly attractive. I would suggest that the use of prestressed concrete for the construction of these possible highways of the future is a foregone conclusion.

We may end with a world rather like that envisaged by H. G. Wells in 'The Sleeper Awakes'; probably no Utopia, since development of ways and means seems to lie always some considerable distance beyond the growth of the population; but had H. G. Wells envisaged prestressed concrete at the time of his prophetic writing, I wonder how far his future world would have differed from that which he so wonderfully described?

Those of you who know prestressed concrete will, I hope, have derived from these lectures some additional incentive to further use or investigation. And I hope that those of you to whom it is a completely new field will have been enabled to see the romance with which this form of construction is invested. If you have, the time I have spent will be more than justified.

I should like to make acknowledgement to the Cement & Concrete Association for the provision of considerable data on which these lectures have been based, for the provision of slides, and for the help and encouragement of members of the Association's staff. I should also like gratefully to acknowledge the facilities granted by the National Coal Board for reproducing the photograph of Killoch Colliery and the permission given by *The Scotsman* to reproduce the photograph of the Sighthill Building at Edinburgh.

RECENT DEVELOPMENTS IN THE VISUAL ARTS IN CANADA

The Neil Matheson McWharrie Lecture by

ALAN JARVIS, B.A.,

Director, National Gallery of Canada, delivered to the Commonwealth Section of the Society on Thursday, 22nd May, 1958, with Sir Gordon Russell, C.B.E., R.D.I., Director, Council of Industrial Design, in the Chair

THE CHAIRMAN: I am in the fortunate position to-night of having to introduce a very good friend of mine. Mr. Jarvis is a Canadian; he was a Rhodes scholar; he was one of Sir Stafford Cripp's secretaries; he is a sculptor; he was an early member of the Council of Industrial Design staff and he was also a Director of a film producing unit, Pilgrim Pictures. He is a former head of Oxford House at Bethnal Green and is now the Director of the National Gallery of Canada. I think you will agree that is a pretty varied and interesting record.

When the National Gallery of Canada was set up, some eighty years ago, a clause was inserted in its Charter making it responsible for any governmental action taken to improve standards of design in industry; and over the last ten years or so the National Gallery has done a great deal in Canada to bolster this art. Some eighteen months ago the National Industrial Design Council, which is responsible to the National Gallery of Canada, moved its Design Centre to new quarters in Ottawa, where it was opened by Sir Vincent Massey, the Governor-General. Mr. Jarvis invited me to attend this function and to speak about our Design Centre in Haymarket and then to lecture on design, as we saw it over here, from East to West in Canada. Previously I had had only a very little knowledge of the eastern seaboard of Canada, and I counted it a privilege to be able to see something of the great prairie towns, and of Vancouver in the West. There is a very live art growing up in Canada—I feel quite certain of that—and I must confess that I am looking forward very much to Mr. Jarvis' lecture.

The lecture, which was illustrated with lantern slides and film excerpts was then delivered.*

THE LECTURE

While placing this map of Canada before you I am reminded of a film which was playing at Oxford during the Michaelmas term of 1938 in which Robert Taylor, travelling down to Oxford in a train, says to a heavy-set 'clubman' opposite, 'Do you realize that you could put the whole of the British Isles into the pan-handle of Texas?', to which the Englishman coolly replied, 'With what object?'. I have an object in beginning with a map, and that is to remind us that Canada is 4,000 miles wide, that it is divided into several geographically differing regions, and that wherever you may be in Canada you are always conscious, in some degree, that to south lies the U.S.A., a nation with a population

* The illustrations shown were, in number and kind, beyond the capacity of the *Journal*; the lecture has accordingly been revised for publication. Mr. Jarvis writes: 'Hoping to avoid printing an over-long catalogue of names without illustrations of the artists' work, I may have omitted reference to individuals whose work contributed substantially to the visual interest of the lecture. To them I extend my apologies'.

ten times greater which is always exerting, consciously or otherwise, some influence on the culture of Canada. It is not, perhaps, surprising that a preoccupation with geography should almost be an inherent Canadian trait. However, to prove that we are not entirely solemn in this preoccupation, I will show an excerpt from the National Film Board production *The Romance of Transportation*, in which you will see a group of younger creative artists transmuting this aspect of our national self-consciousness by means of brilliant visual humour[1].

What does not appear on the map is the vital fact that Canada is a bi-lingual, bi-cultural country. I feel certain that a French Canadian, lecturing to a comparable society in Paris, would illustrate and emphasize certain different facets of the complex of Canadian culture, yet I am equally sure he would earnestly hope to show, as I do, that though there may not yet be a Canadian culture (and I doubt if either of us very much cares if there ever is), there is a rich variety of regional cultural or creative activity to be found in Canada, of which we, individually, and as a nation, can be reasonably proud.

Perhaps I should present my credentials for having said this. I returned to Canada in the spring of 1955 after 17 years in England and Europe, and since then I have had the exhausting privilege of travelling twice from coast to coast, visiting almost every centre, large and small, where there is an art gallery, art centre or group of people interested in the arts. As a result I can testify that there is an astonishingly widespread, intelligent interest in the visual arts, one symptom of which is the increase in the building of galleries. I would instance Fredericton, N.B. (where Lord Beaverbrook is building a permanent gallery to house his collection of British painting and which will also show travelling exhibitions), Regina, where the Norman MacKenzie Memorial Gallery has been enlarged and an excellent art school incorporated (the whole designed by a brilliant young team of architects, Izumi, Arnott and Sugiyama), and Victoria, B.C., where the provincial centenary is being commemorated by the building of a great addition to the city gallery. Another indication of public interest in the arts is the fact that the National Gallery of Canada—which performs many of the functions which in Britain are the responsibility of the Arts Council—is circulating some 55 exhibitions to approximately 120 different centres, and this by no means meets all the demands for such a service.

At this point I think I should make some brief remarks on support for the arts at government level; for, after all, in a democracy parliamentary support must be taken as a measure of public support. I have just mentioned the National Gallery's programme of circulating exhibitions (which is, of course, supported by travelling lecturers, film programmes, circulating slide-collections and so on) which is directly supported by federal funds to the extent of about half a million dollars a year. In addition to this operating budget, the Gallery has been given purchase funds of a very generous size (the Gallery has spent very nearly one and a half million dollars on purchases since I took office) wherewith it has been able to make some very important acquisitions, principally works by Simone Martini, Filippino Lippi, Memling, Quentin Matsys, Maes, Rembrandt,

Rubens, Chardin and Canaletto from the collection of the Prince of Liechtenstein, which have raised the status of the Gallery from that of an interesting provincial collection to one of international standards. It was interesting to study *Hansard* when the votes for National Gallery purchases were being discussed, and to note the all-party agreement that Canada must, now, try to take her place culturally, as well as politically, as a 'middle-power'. A further reflection of this attitude was seen in the spring of 1957, when Parliament established the Canada Council (for the promotion of the Arts, Letters and Humanities, to give its full title), in fulfilment of the recommendations of the Royal Commission of 1951 which became known as the Massey Commission, after its Chairman, the Rt. Honble. Vincent Massey, now Governor-General. The Council has been voted a capital fund of one hundred million dollars, fifty million of which is to be given in the form of capital grants to the universities. The other fifty million has been invested and the income is to be devoted to scholarships, grants-in-aid to art galleries, orchestras, ballet companies, etc. It has already, in its first year, set a pattern of creative patronage for the arts which will prove to be of inestimable benefit to the whole Canadian community.

Another instance of federal help is the National Industrial Design Council, which was established in 1947 under the wing of the National Gallery rather than, as in Britain, the Department of Trade and Commerce, and which has had its own permanent Design Centre in Ottawa since 1953. The N.I.D.C., like the Council of Industrial Design in Britain, keeps a design index, gives annual design awards to individual products judged worthy of this distinction by an independent jury, and presents a series of exhibitions at the Design Centre, most of which are also circulated throughout the country. There are also an Association of Canadian Industrial Designers, comparable to the Society of Industrial Artists in Britain, and a growing professionalism among Canadian designers as well as an increasing appreciation from manufacturers and public of the rôle which the industrial designer should play. It must, however, be admitted that there is relatively little original *Canadian* industrial design. This is understandable when you realize that Canada is not primarily concerned with manufacturing consumer products, and that such as are made in Canada are largely manufactured by American- or British-owned subsidiaries whose parent companies supply the designs. However, in certain fields, particularly those of furniture and aluminium, a number of Canadian designers are beginning to achieve international recognition, and the names of Robin Bush, Julien Hébert, Jan Kuyper and Robin Kaiser should be mentioned. One of Bush's most interesting assignments was the furnishing of workers' flats and hostels for the great new town of Kittimat in British Columbia. This project was shown at the XIth Triennale at Milan in 1957 and was well received by the critics.

The government has followed up its concern for the fine and applied arts with the establishment, in 1956, of the Canadian Housing Design Council, financed by a Crown corporation under the National Housing Act. Unfortunately, one million post-war houses had already been built when the Council was established, and of that number only 2 per cent were architect-designed.

FIGURE 1. *Garden homes, Don Mills, Ontario. Architects: John B. Parkin Associates*

Therefore you will find, everywhere in Canada, large, depressing suburban areas over-densely spread with 'builder's houses'—the inevitable result of the post-war economic boom and the lack of planning legislation. The Housing Design Council, however, has embarked on a large-scale propaganda operation directed to builders and public, the chief instrument of which is a series of provincial and national awards for good design in various price categories. The best example of a design-award house is that by James Murray of Toronto for a house costing approximately $24,000 (Figure 1), built in Don Mills, one of the few suburbs in Canada where good community planning and a high standard of domestic and industrial architecture can be found, thanks to the supervising architects, John B. Parkin Associates, and to the foresight of the financial interests concerned. (There is one more federal agency which I propose to mention, the National Film Board, but I will reserve this until later and continue with architecture.)

It is most difficult to find any coherent patterns of development in contemporary Canadian architecture, since the buildings themselves are spread across a geographical strip approximately one hundred miles deep and four thousand miles wide. However, in the course of preparing this paper, I have collected some hundreds of slides; and in reviewing this material in one place

and at one time I have come to the conclusion that there is a volume of creative work in the architectural field commensurate with our population and certainly comparable to developments in the other arts. From this wealth of material it is difficult, and sometimes invidious, to single out particular works as representative of their regions. Special mention should, however, be made of the work of James Murray in both domestic and church architecture (it is interesting to note that church architecture in Canada generally reflects the greatest experimentation); of Irving Grossman, Geoffrey Massey, Fred Lassere and Douglas Simpson in the domestic field; of Philip Carter Johnston and W. R. Ussner in church design; and of the John B. Parkin Associates, Pentland and Baker, Semmens and Simpson, Page and Steele, and Fleury and Arthur for the design of public buildings such as factories and schools—especially Parkin's brilliant design for the Salvation Army headquarters in Toronto. It is not within the compass of my subject to discuss the remarkable movement toward maturity which has taken place in the Canadian theatre, but I do wish to show the building (architects: Rounthwaite and Fairfield) which houses the now internationally-known Stratford company, a theatre-in-the-round with a free-standing stage which is one of the few fresh creations in theatre architecture to be found anywhere in the western world during the last half century (Figure 2).

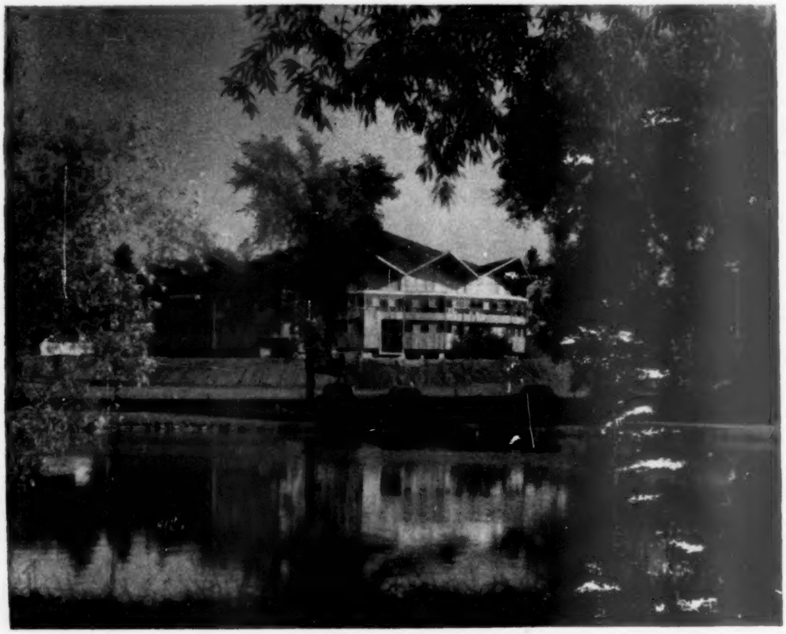


FIGURE 2. *Shakespearean Festival Theatre, Stratford, Ontario. Architects: Rounthwaite and Fairfield*

FIGURE 3. *Headquarters building, British Columbia Electric Company, Vancouver. Architects: Thompson, Berwick and Pratt*

Also, in the course of reviewing modern Canadian architecture, I have been struck by a number of interesting collaborations between architect and artists, perhaps the most impressive example being the British Columbia Electric Company's headquarters building in Vancouver (Figure 3). The architects for this were Thompson, Berwick and Pratt, with the distinguished painter-designer B. C. Binning as artist-consultant. This building is studied in every detail, so that 'it is controlled by design from the curb to the top of the flag-pole'. Unhappily a black-and-white illustration cannot do justice to a building in which the welding of grandeur to elegance results largely from Binning's exquisite use of colour-patterns of mosaic brilliantly integrated with the architectural forms. Incidentally, it is worth noting how this versatile artist has combined architectural and mural design equally successfully on a more intimate scale in his own home.

Among other collaborations I would single out for special mention York Wilson's and Jack Nichol's murals for the Salvation Army headquarters, Toronto (architects: John B. Parkin Associates), Kenneth Lochead's mural for Gander International Airport (architects: Durnford, Bolton, Chadwick and Elwood for the Department of Transport), Aba Bayefsky's mosaic mural for Northview Collegiate, Toronto (architects: Pentland and Baker), Mario Merola's mural for the cocktail bar in the Canadian Pavilion at Brussels (architect: Charles Greenberg), and a charming example of the use of child art in the designs for a mural wall surrounding a swimming pool designed for the Department of Parks and Recreation in Toronto (architects: Wilson and Newton; designer: Yusing Y. Jung). The brilliant collaboration between the designer Norman Slater and the sculptor Louis Archambault raises a problem of Canadian sculpture about which, alas, I cannot speak so warmly.

That sculpture has not thrived in Canada cannot be because, as Paul Valéry once lamented, 'the mother, architecture is dead . . .", for we have seen a great willingness on the part of Canadian architects to collaborate with painters and sculptors. I think the fact is that prior to 1945 sculpting simply was not an

FIGURE 4. *Part of sculptured mural screen by Louis Archambault in association with Norman Slater, in the Canadian Pavilion, Brussels Exhibition*

economic profession in Canada, few students were attracted to it and few good teachers were available. Now that there is at least a potential demand for their services, few trained sculptors are ready to come forth. One conspicuous exception is Louis Archambault, whose work will already be familiar to Londoners who saw his large sheet-iron Bird at Battersea Park in 1951 (it was even the subject of a Low cartoon), and who, in association with Norman Slater, created the 120 ft. terra-cotta mural wall which leads the visitor into the Canadian Pavilion at Brussels (Figure 4). In addition to Archambault there is only one other young sculptor, Anne Kahane of Montreal, whose work can be regarded as of international standard. Examples of her work are being shown this summer at the Canadian Gallery in Brussels and in the Canadian Pavilion at the Venice Biennale. In fairness, I should mention the names of the mature Canadian sculptors who have maintained high standards of more traditional work—Frances Loring, Florence Wyle, the late Emmanuel Hahn and Elizabeth Wyn Wood (who, as I know from studying with her, is also a fine teacher)—so that the Canadian scene is not wholly devoid of public sculpture of distinction. Nevertheless, it seems to me that only the two younger sculptors I have mentioned have done work which is comparable in merit to that of the post-war generation of painters and graphic artists.

Canadian painting came into its own, so to speak, a generation ago with the founding by the Group of Seven of a national school of painting which was inspired by 'the North'—the fir- and pine-fringed lakes and rocky hills of the great pre-Cambrian shield. (Dr. A. Y. Jackson, one of the original members of the group, spoke to the Commonwealth section about this development in 1948.) The North country continued to be the dominant subject in Canadian painting until the 1930s, and indeed it seemed at one time that you had only to paint twisted pine trees or bleak rocks to be a 'Canadian' artist. This unthinking nationalism died with the Second World War, a new inter-nationalism has taken its place, and Canadian art is now no longer so intimately linked with geography as it once was. However, the romantic appeal of the North will undoubtedly always interest and inspire certain creative people; a recent example of its power is the National Film Board's deeply moving documentary on the Klondyke Gold Rush, *City of Gold*, which has by now become world-famous and an international prize-winner.[2]

As I said, the self-conscious Canadianism of the Group of Seven has passed and a new internationalism has taken its place, but in Canada, as elsewhere with contemporary art, it is difficult to make many useful generalizations about the current scene. Perhaps it is especially difficult in the case of Canada, for we are, in effect, equally susceptible to influences from London, New York and Paris. It is safe to say that the English Canadians have tended to look to London and New York (and a few toward Mexico), while the French Canadians have looked toward Paris. The most dramatic contrast between pre- and post-war painting is to be found in Quebec, where the intellectual freedom of modern France and the experimentation of the School of Paris have profoundly influenced a generation of artists which before the war had lived in a society more rigid in its

habits and thoughts than any elsewhere in North America. Three French Canadian painters have achieved international reputations (two of them are familiar to London gallery-goers)—Pellan, Borduas and Riopelle, and they have also had a vital influence in Canada. Borduas, in an explosive manifesto, *Refus Global*, published in 1948 (and which cost him his provincial teaching job), launched a school of painters known as *automatistes* which stirred the art worlds of Montreal and Quebec and, although he is now painting in France, his influence is still deeply felt.

FIGURE 5. Medieval landscape, *by Jack Shadbolt*, 1957.
Oil on canvas. Guggenheim Canadian Prize, 1957

In Ontario many of the younger artists have been influenced by the currently fashionable schools and theories of New York, particularly by the teaching of Hans Hofman. In British Columbia it is inevitable that influences from the Pacific coast American artists, such as Mark Tobey, should have influenced a painter like Jack Shadbolt (Figure 5). In fact, the cross-currents of influence are many and complex, and valid generalization is impossible. This was clearly demonstrated in the case of our selection of artists to be shown in the Canadian Pavilion at the Brussels Fair.

It was decided that we should emphasize the work of artists who had 'made their mark since 1939', and the selection committee, by a system of balloting, arrived at a list of 23 persons. The majority of these are painters, two are sculptors, and five were chosen to be represented largely or solely by drawings and prints.[3]

Analysing the list geographically it is interesting to note how the artists from

Montreal and Vancouver now overwhelmingly outnumber those from Toronto, the centre of *avant garde* painting in the days of the Group of Seven: it is small wonder that there was an outcry from Toronto artists when the list was published! An analysis of the list from an aesthetic point of view simply reveals the impossibility of generalization, for the styles represented vary from Riopelle's or Borduas' 'action painting' to the magic realism of Colville and the surrealism of Pellan, with the romantic realism of de Tonnancour (Figure 6) and Nichols somewhere in between. However, I feel I may be allowed to make one general remark (and may I remind you that I came back to revalue Canadian art with the detachment of one expatriate for 17 years): we now have in Canada a substantial number of artists (not all of them, by any means, on the Brussels list) who are producing work of an artistic standard which bears comparison with the best work being produced in any country in the world. This is a view which has been supported by a number of disinterested critics from the United Kingdom, the U.S.A. and Europe.

I dislike a too rigid separation of the 'fine' arts from the applied or practical arts, and I should therefore not wish to conclude this widely-ranging survey without referring to a field of creative endeavour in which Canadians have achieved international recognition—the documentary film. Most film-making in Canada is sponsored by the government-financed National Film Board

FIGURE 6. Winter landscape, *by Jacques de Tonnancour, 195[illegible]. Oil on canvas*

(although at least one private company, Crawley Films Limited, has also done very distinguished work) which grew out of wartime information services. The N.F.B. owes much of its success to the initial impetus and direction given it by that remarkable Scotsman, John Grierson. The Board has maintained, over the years and under a succession of Film Commissioners, a tradition of giving complete creative freedom to even the youngest of its film-makers, with such admirable results as you have warmly received to-day. One cannot help but praise an agency which has developed the talent of an artist such as Colin Low (aged 32) and which gives him complete freedom to create, as it has also done in case of Norman MacLaren, whose work is so well known throughout the world that I need make no further comment on his creations, one of which you have just seen.[4]

REFERENCES

1. *The Romance of Transportation:* Producer, Tom Daly; Writer-Narrator, Guy Glover; Design, Bob Verral; Characterization, Wolf Koenig; Supervision, Colin Low.

2. *City of Gold:* Producer, Tom Daly; Script, Pierre Berton; Direction, Colin Low with Wolf Koenig; Music, Eldon Rathburn.

3. The complete list is as follows: Louis Archambault, Montreal; Léon Bellefleur, Montreal; B. C. Binning, Vancouver; Bruno Bobak, Vancouver; Paul-Emile Borduas, Montreal and Paris; Alexander Colville, Sackville, N.B.; Jean Dalaire, Montreal; Albert Dumouchel, Montreal; Anne Kahane, Montreal; Jean-Paul Lemieux, Quebec; Kenneth Loachhead, Regina; Jean-Paul Mousseau, Montreal; Jack Nichols, Toronto; Alfred Pellan, Montreal; Joe Plaskett, Vancouver; Jean-Paul Riopelle, Montreal and Paris; Goodridge Roberts, Montreal; William Ronald, Toronto and New York; Jack Shadbolt, Vancouver; Takao Tanabe, Vancouver; Gentile Tondino, Montreal; Jacques de Tonnancour, Montreal; Harold Town, Toronto.

4. *Begone Dull Care.*

DISCUSSION

THE CHAIRMAN: I am sure you would wish me to thank our lecturer to-night on behalf of everyone here for bringing into the room a real feeling of the atmosphere of this tremendous Dominion. I am glad Mr. Jarvis showed illustrations of buildings as well as painting and sculpture—though what we have not seen, by concentrating on the buildings themselves, is their background: the beauty of the wild country, especially in Vancouver, where you get almost primeval forest coming right down to the suburbs of the city. In fact, I am told that inhabitants who hear on moonlit nights a garbage can lid fall off, say, 'It is just one of those damn bears again'.

I was particularly glad myself to see the illustrations of the new theatre at Stratford, Ontario, because there again it is situated in the most enchanting little park. I went a little out of my way to see it. The first thing I saw was an immense notice at the station which said 'The World Famous Shakespearean Festival'. As I have a house eleven miles from Stratford-on-Avon I wondered whether I had been mistaken or whether there was perhaps another one somewhere else!

The vote of thanks to the Lecturer was carried with acclamation.

SIR SELWYN SELWYN-CLARKE, K.B.E., C.M.G., M.C. (Chairman, Commonwealth Section Committee): May I inform the meeting of two messages which have been sent to us? One is from Lady Pigott, who endowed this lecture in memory of her first husband, Neil Matheson McWharrie. Lady Pigott has written to express her regret that she could not be present to hear Mr. Alan Jarvis, to whose lecture she had been looking forward. The other message comes from Miss Mary Macgillivray, a former and most valued member of the Commonwealth Section of the Society, who has since returned to Canada, and who wrote to say that she felt this lecture would be a success. We can assure Miss Macgillivray that her prophecy has been more than fulfilled. We have had a fascinating lecture from Mr. Jarvis and we are very grateful to him.

Will you now join with me in thanking our Chairman, Sir Gordon Russell, for having so ably presided over our proceedings this evening?

The vote of thanks to the Chairman was carried with acclamation, and the meeting then ended.

GENERAL NOTES

ANTIQUES EXHIBITION IN WOLVERHAMPTON

Sir Charles Wheeler, P.R.A., visited the Art Gallery and Museum of his home town, Wolverhampton, on 22nd October and opened an Exhibition of Antiques from Historic Houses and Private Collections in South Staffordshire and South Shropshire. This is a notable exhibition, four extensive galleries being filled with costly treasures rarely, if ever, to be seen in public, and it is to be hoped that other towns will attempt similar displays with equal enthusiasm. One's only regret is that the unique opportunities concerning Wolverhampton's own past history of fine craftsmanship have been overshadowed by the more obvious attractions of splendid furniture and lovely silver and porcelain. One looks in vain for the handsomely decorated japan work and papier mâché for which the town was world-celebrated for almost a century. The list of notable artists is long, including such celebrities as Edward Bird, R.A., and Joseph Barney, flower painter to the Prince Regent. These and other artists passed from industrial painting to working on canvas. Wolverhampton was long celebrated too, for its steel jewellery, in designs that were copied by Parisian jewellers. The royal families of Europe commissioned such jewellery from George Warrilow of Wolverhampton. Another time, perhaps, it might be possible to include some exhibits representative of these and other crafts of Georgian and Victorian days.

Painted enamels from nearby Bilston as well as the more widely celebrated Battersea are included in the Exhibition. Fifty handsome examples have been lent from the well-known Mander collection. These include a peculiarly delightful vase tea caddy painted with posies and butterflies, one of the first large pieces to be hand raised from copper plate. A little-known wall decoration of the early 1790s and early 1800s is noticed in the black papier mâché panel set with three vivid painted enamel landscapes. Rarely does a complete example come to light. Scent bottles with gilded pinchbeck stoppers, snuff boxes, étuis, a spy glass and a pair of small candlesticks are to be seen in the show cases with a further selection of fifty from the collection of Mr. F. C. Hill of Tettenhall.

A display of 44 outstanding pieces from the Cyril Kieft collection of Nantgarw and Swansea porcelain, the most comprehensive outside Wales, includes the Nantgarw *sucrier* made and decorated by William Billingsley for submission to the Committee for Trade and Plantations when making his unsuccessful application for a state subsidy in 1814. This piece was intended to prove to officials that Billingsley's porcelain made at Nantgarw could then compete on equal terms with Sèvres. Billingsley described this porcelain as 'a combination of the Qualities of the best French Porcelain, Whiteness and Transparency with the firmness and closeness of Grain peculiar to the Saxon or Dresden Porcelain'.

The Tompion and other clocks and the vast assembly of furniture will attract connoisseurs. Among the interesting miscellany of treasures is a fascinating Charles II jewel box of burr mulberry enriched with silver mounts; a bronze Winchester gallon measure inscribed 'Town of Wolverhampton 1802' discovered near Salisbury; the kettle drum which belonged to the Royal Wenlock Volunteers in 1804 and is now in the possession of Lord Forester; and an oak rocking-horse made by the estate carpenter from Chillington timber about 150 years ago and guaranteed not to tip over.

The exhibition remains open until 22nd November.

G. BERNARD HUGHES

A NEW PATTERN OF PATRONAGE

The precarious financial position of the arts in Britain and their need for a greater measure of public recognition and support are again emphasized in the thirteenth

annual report (1957–8) of the Arts Council, which examines the remedial possibilities of *A New Pattern of Patronage*. Recognizing the steady decline of the wealthy private patron, the Secretary-General, Sir William Emrys Williams, foresees that industry could become the Maecenas of the future, bearing a responsibility additional to those already carried by government and municipality. Industrial patronage of the arts has, in fact, noticeably increased since the war, and 'an annual £50,000 is a fair estimate' of its extent in recent years (a sum which might be greatly multiplied if such subscriptions were tax-deductible, as they are in the United States). It is not solely, however, because it possesses the monetary resources to undertake large-scale tasks beyond the present capacity of the Arts Council that Sir William looks to big business:

> Patronage . . . works best when it has many centres of initiative, when its government is divided among several bodies rather than consolidated in one. A plea which fails in one quarter may succeed in another; the conservative habit of one distributing body may be offset by the adventurous outlook of a different tribunal. In its heyday the patronage of Popes and Grand Dukes was often strongly flavoured with an element of sheer caprice which sometimes brought off miracles of art. Caprice is a luxury which an Arts Council must deny itself—but not so an independent industrial patron. Some good causes need slow and patient nourishment before results can be expected—and these can be more easily adopted by a private than by a public body. The private body can gamble on long shots; a government agency is liable to public criticism if it does so. It is in this sense that the new industrial patrons, including independent television, can constitute a Third Force of patronage.

Whether or not it is in response to the hint given in last year's Report (see *Journal*, 25th October, 1957, p. 941), Independent Television has this year raised a joint levy of £100,000 for the support of the arts, thereby, in Sir William's phrase, 'recognizing a principle analogous to that of reafforestation'. This munificent act may well stimulate other great corporations.

Though the opera crisis which has figured so prominently in the public press also tends to overshadow the Report, it is nevertheless clear from this survey of the year's activities that the Council is continuing to lay out its own funds effectively and with discernment. A note of deep regret is sounded in the valedictory to Mr. Philip James who, after 16 years as Art Director, has left the Council to become first Director of the Rothschild bequest at Waddesdon Manor. One of Mr. James's outstanding achievements has been the initiation and development of the Council's collection of contemporary painting and sculpture, which has furnished a series of very popular exhibitions.

Copies of *A New Pattern of Patronage*, price 2*s* 6*d* each, may be obtained from the Arts Council at 4 St. James's Square, or from H.M. Stationery Office.

BARNETT FREEDMAN AND JOHN MINTON: TWO MEMORIAL EXHIBITIONS

Until 12th November the Arts Council is showing two memorial exhibitions at 4 St. James's Square: one devoted to Barnett Freedman (1901–58) and the other to John Minton (1917–57). The former is the first exhibition of Freedman's painting to be held, and includes some of his early landscapes and paintings executed when he was an official war artist. The price of admission to this double exhibition (which will later be shown at a number of provincial galleries) is 1*s*., and the opening times are as follows: Mondays, Wednesdays, Fridays, Saturdays, 10 a.m. to 6 p.m.; Tuesdays, Thursdays, 10 a.m. to 8 p.m.

SIR DAVID WILKIE EXHIBITION

The Royal Academy is holding an exhibition of works by Sir David Wilkie, R.A. (1785–1841), in the Diploma Gallery at Burlington House until 10th December. This is the first of a series of exhibitions which will be devoted to Royal Academicians

of the past, and it includes nearly all the pictures shown at the National Gallery of Scotland during the recent Edinburgh Festival. Mr. Nevile Wallis briefly recorded his impression of this display in the last issue of the *Journal* (p. 879). Admission costs 2*s*. 6*d*.

THE CHARTERED SURVEYORS GOLD MEDAL AND PRIZE, 1958

The Chartered Surveyors Gold Medal and Prize is again offered for a paper which shows original thought, and makes the best contribution to the advancement of knowledge, on one of the following subjects: (1) 'The Place of Agriculture in Land Economy'. (2) 'The Realization of Positive Town Planning'. (3) 'The Costs of Building'. (4) 'The Influence of Legislation on Land Development'.

Entries may be submitted by any person ordinarily resident within a country of the British Commonwealth or in the Republic of Ireland. They must be sent, not later than 30th April, 1959, to the Secretary, The Royal Institution of Chartered Surveyors, 12 Great George Street, London, S.W.1, from whom entry forms and full details of the specified subjects should be obtained.

BRIT. I.R.E. JOURNAL ABSTRACTS

The British Institute of Radio Engineers has published a new edition of *Selected Abstracts from the Journal of the Brit. I.R.E.*, 1946–58. This work of reference provides informative abstracts of the principal papers and reports which have appeared in the Institution's *Journal* since the end of the war, and includes papers scheduled for publication in the remaining issues of this year's volume. The 529 main entries cover a wide range of subjects which concern the radio and electronics engineer. The section on automatic computers is particularly detailed. Copies of *Selected Abstracts*, price 3*s* 6*d* each, may be obtained from the Institution at 9 Bedford Square, W.C.1.

THE MODULAR ASSEMBLY

Members of the building trade are invited to inspect the Modular Assembly, which has been erected at 27–28 Albert Embankment, S.E.11. This is an experimental structure designed to test the use in assembly of a variety of components manufactured to sizes that are related to multiples of four inches. The fundamental purpose of modular co-ordination is to achieve economies in building, and it is notable that thirty-five firms, all of them members of the Modular Society, have participated in this investigation and shared its cost.

The Modular Assembly is on view between 10.30 a.m. and 6.30 p.m. from Mondays to Fridays until shortly before Christmas.

OBITUARY

We record with regret the deaths of five Fellows of the Society.

SIR ARTHUR EVANS

Colonel Sir Arthur Evans, who died on 25th September in his sixtieth year, was for long an active and familiar figure in the House of Commons and closely associated with the British Group of the Inter-Parliamentary Union. After distinguished service in the First World War—he enlisted before he was 16—he entered Parliament in 1922 as National Liberal Member for East Leicester. The following year he became a member of the Conservative Party, in whose interest he represented Cardiff South from 1924–9 and from 1931–45. Twice Chairman of the Welsh Parliamentary Party, Evans had also served for a number of years on the governing bodies of the University

of Wales, the National Museum of Wales and the Welsh National Library. He was knighted in 1944.

Sir Arthur Evans was elected a Fellow of the Society in 1927.

SIR JOSEPH KAY

Sir Joseph Aspden Kay, K.B.E., who died on 1st October, aged 74, will be recalled by many as a prominent member of the European business community in Bombay who also played a conspicuous part in its public, social and sporting life. Born and educated in Bolton, at an early age he became associated with the cotton trade, and went out to India as managing director of W. H. Brady Ltd. He was thrice Chairman of the Bombay Millowners' Association and four times Vice-President of the Indian Central Cotton Committee. In 1923 he was appointed an employers' representative in the Indian Delegation to the International Labour Conference at Geneva. In 1926 he was President of the Bombay Chamber of Commerce. These years saw an increasing demand for his counsel in public affairs. He was a member of the Provincial Legislature in 1925–6, and also served as a Justice of the Peace and an Honorary Presidency magistrate. In 1926 he became Chairman of the Back Bay Enquiry Committee, and subsequently acted on several important public boards in Bombay. His keen interest in the volunteer movement was evidenced by his own service in the Bombay Light Horse, from which he retired in 1934 with the rank of Captain.

Sir Joseph was elected a Fellow of the Society in 1927. In 1952 he read a paper on 'India's Cotton Textile Industry' to a joint meeting of the Commonwealth Section and the East India Association.

THE REVEREND DR. G. H. RALEY

The Reverend Dr. G. H. Raley, D.D., who died in Vancouver recently at the age of 95, had spent the greater part of his life as a missionary among the Indians on the British Columbia coast. Born in Yorkshire, he emigrated to Canada as a boy, and entered the Methodist ministry in 1884. He began his long mission at the remote village of Kitimat, where he devoted himself to every aspect of the spiritual and material welfare of the Indians and produced a dictionary of their dialects. In 1896 he moved to Fort Simpson, and from 1914–34 he was Principal of the Coqualeetza Indian School.

Dr. Raley was elected a Fellow of the Society in 1931.

COLONEL E. R. RIVERS-MACPHERSON

Colonel Ernest Ronald Rivers-Macpherson, O.B.E., died in Ottawa on 17th August, aged 76. He retired from the army in 1947 after a distinguished career, which included action in both world wars and periods of service in Africa and India. Always prominent in Scottish Clan activities, at the time of his death he was Chairman of the Canadian Branch of the Clan Macpherson.

Colonal Rivers-Macpherson was elected a Fellow of the Society in 1934.

DR. MARIE STOPES

Dr. Marie Stopes, D.Sc., Ph.D., who died on 2nd October at the age of 75, made herself very widely known as an outspoken advocate of family planning and the founder of the first birth-control clinic. Though undisguidedly emotional in its approach, and open to criticism on religious grounds, her teaching had an unprecedented influence. Perhaps her real achievement was to have induced a climate of opinion favourable to the open discussion of a highly controversial subject.

Marie Carmichael Stopes was by training a botanist. She had a distinguished academic career at London and Munich, followed by periods of teaching at the Universities of Manchester (where she was the first woman appointed to the science

staff), Tokyo, and London. In these early years she was known, within a necessarily limited circle, as the author of some able works on palaeobotany; it was not until 1918 that she came into public notice by publishing *Married Love*, which, like its successors (notably *Radiant Motherhood* and *Contraception: its Theory, History and Practice*) had a huge sale. The financial success of these works enabled her to found the Mothers' Clinic in Holloway, and subsequently to initiate the establishment of similar centres elsewhere.

Dr. Stopes published several volumes of verse, in which may be detected the influence of Lord Alfred Douglas, of whom she wrote an admiring study in 1949. Her interest in scientific subjects remained alert to the end of her life, and she contributed to discussion at meetings of this Society on several occasions. She was elected a Life Fellow in 1949.

CORRESPONDENCE

'STONES OF BRITAIN'

From *Lt.-Col. B. C. G. Shore, F.A.M.S., Hon.F.I.Q.S., L.R.I.B.A., 20 Wheatley Street, London, W. 1.*

After we had read the review of my book *Stones of Britain*, signed by Mr. D. A. G. Reid, in your August issue, a friend of mine has urged me to write and ask Mr. Reid why he states that I have neglected the scientific study of the behaviour of building stones.

May I ask him, in his courtesy, to enlighten me with some, at least, of the particular instances on which he relies for what seems to us to be a strange generalization? I feel that my intuition must be of an order altogether more remarkable than I dared hope if, as he says, I arrive at my conclusions and facts whilst caring little about science or scientists.

I should be interested to know some of the significant factors which he considers I have left out of account.

Mr. D. A. G. Reid, B.Sc.(Eng.), M.I.Struct.E., A.M.I.Struct.E., Principal, Brixton School of Building, writes:

The attitude of the author towards science and scientists was judged from certain general characteristics of his book.

1. He has a way of making assertions of doubtful validity. Examples of such assertions are: (*a*) that the movement of water in limestones becomes more 'free' in the course of time, (*b*) that there have been inexplicable failures of Portland cement complying with the requirements of British Standard, (*c*) that lime mortar made from very fine calcium carbonate is demonstrably more injurious (to stone) than lime mortar made from limestone, (*d*) that there can be no difference of opinion as to the usefulness of creating damp-proof courses with high capillary tubes, (*e*) that a water-repellant will have exceptional qualities as a stone preservative. These are all matters of the first importance to the subject of the book. The author rarely cites illustrative examples in support of his assertions and he offers no critical appraisal of the significance of his experience in relation to that of others in the same field.

2. His only appreciation of the work of other scientists concerns the development of silicones. Apart from disparaging references to the work of the Building Research Station, the author ignores work done both in this country and abroad on the deterioration of natural building stones. On page 245 he writes a condemnation of earlier work on waterproofing treatments as if he alone had approached this problem with 'clear thought and reasonable knowledge'. Much more work has been done than he implies on the behaviour of moisture in porous materials and one would have expected him to take cognisance of this in its bearing on the subjects of rain penetration and stone preservation.

3. While it is understandable that the author should wish to provide simple explanations for the benefit of some of his readers, his notes on the physical and chemical causes of decay (pages 16 to 20), his references to interfacial tension (pages 24, 246 and elsewhere) and the pages dealing with Portland cement and its uses (pages 164 to 176) are far from adequate and often misleading. Important matters, such for example as the sources and effects of salt-contamination, are not dealt with.

NOTES ON BOOKS

THE PENROSE ANNUAL 1958. *Edited by Allan Delafons. London, Lund Humphries, 42s net*

This is the first *Penrose* from its new editor, Mr. Allan Delafons, and it inevitably invites comparison with the work of the late R. B. Fishenden. Despite the statement on its wrapper that the annual now enters a new stage in its progress, it is evident that the basic formula is much the same as Fishenden left it, though with a change of quality which may be due to a different editorial policy as well as a different personality. Mr. Delafons does not yet possess either the range of knowledge or the urbanity of style that distinguished his predecessor, and the result appears to be a *Penrose* of more limited range and superficial view; these attributes may arise from a desire to make the annual more popular in its appeal, and if this is the case, it is a great pity.

As in previous years, the text is arranged in three parts, a general section first, followed by a technical section, with 'Illustrations of the Year' last, and apparently of so little importance that they are classed with the advertisements in not being mentioned in the list of contents.

It seems to me that most of the articles are shorter than usual, and that many have ambitious titles that cannot possibly be warranted by the length of the text—what, for example, can be done in two and a half pages for 'Advertising in the Atomic Age'? Voysey's wallpaper designs also deserved more room, but with four and a half pages, the subject is comparatively generously treated. I feel that Peter Floud could say considerably more about this aspect of the work of one of the most interesting of Victorian architects. However, there is a generous allowance of illustrations, in both colour and monochrome half-tone—illustrations to the text are, as they have always been, an important part of every article in this issue of *Penrose*, and there is no niggardliness in quantity or in reproduction.

Newspaper printing is perennially interesting and here it is discussed in an article on Mr. Edwin W. Shaar's Imperial type, and in two technical articles on colour illustration. Mr. Shaar has tried to produce a type less rigid than the mechanical Ionics and Ideal that have their origin, as far as newspapers are concerned, in the technical necessities of printing. Mr. Delafons writes on colour printing in newspapers in the U.S.A. and in England, and as an example of the 'wealth of colour' available to American advertisers in their own country, includes a full-page colour advertisement which I consider an example of bad process engraving, bad colour, bad register, and bad printing. Two other examples, from the *Liverpool Daily Post*, show a superior technique on this side of the water. Both are surpassed by some examples of colour webb offset on newsprint. It seems to me that satisfactory colour printing in newspapers must await the adoption of suitable offset or gravure processes.

Among the technical articles, one on 'Map Production in the Ordnance Survey' and another on bank note engraving are particularly interesting because they deal with aspects of printing that are little known, though their products are familiar. There are suitable illustrations, including a sample bank note—not, unfortunately, cashable.

I suspect that the Illustrations of the Year are, in fact, nothing more than a collection of free samples provided by selected printers, engravers, etc., a sort of feeble survival

of the vigorous printers' specimen exchange system of the eighties. These are a dull lot, the usual four-colour half-tones demonstrating the excellence of somebody's inks or somebody's printing. Among them the four-page insert from the Westerham Press is outstanding, both in design and in printing. This section of the annual should be taken in hand by the editor, to become truly what it claims to be, an editorial review of the illustrations of the year.

Well presented in the excellent typography of Mr. Arthur Spence—who has produced a handsome volume—the various articles are legible and readable both typographically and literally, and the book maintains its reputation as an annual delight.

SEÁN JENNETT

SHORT NOTES ON OTHER BOOKS

ARSHILE GORKY. *By Ethel K. Schwabacher. New York, The Macmillan Co. (for Whitney Museum of American Art)*, 1957. 59*s* 6*d net*

The author, who was a pupil and friend of Gorky, has produced an intimate study of the life and art of this American painter, who died in 1948. With 7 plates in colour, and 80 illustrations in black and white.

FIGURE DRAWING COMES TO LIFE. *By Calvin Albert and Dorothy Gees Seckler. New York, Reinhold*, 1957. (*London, Chapman and Hall*, £3 *net*)

Prepared for the use of art students, amateur and commercial artists, and teachers. The emphasis is on progressive experiment, and many of the drawings illustrated were made by art students in their first year of study.

NEW CHEMISTRY. (*A Scientific American Book.*) *London, Bell*, 1958. 13*s* 6*d net*

The sixteen articles here printed first appeared in the *Scientific American*. They describe some recent developments in modern industrial chemistry, including 'hot-atom' chemistry, chemical analysis by Infrared, Ion exchange, Silicones and Fluorocarbons.

LANDSCAPE AND MARINE PAINTING (IN OIL AND WATER-COLOUR). *By Claude Muncaster. London, Pitman*, 1958. 45*s net*

Though the author describes technique, this plays here a rôle subordinate to his main purpose, which is to direct and heighten the reader's response to the poetry of Nature. The book includes many plates, some in colour, and a perceptive chapter on 'The Old Masters' Approach to Landscape and Marine Painting'.

PAINTING THE FIGURE IN WATERCOLOUR. *By Herb Olsen. New York, Reinhold*, 1958. (*London, Chapman and Hall*, £4 *net*)

An extensively illustrated manual of simplified instruction, which includes sections on materials, basic forms, use of shadows and draperies, backgrounds and outdoor scenes. The author is an experienced teacher and painter.

HOW TO DRAW ROCKETS AND SPACESHIPS. *By Charles Sargeant. London, The Studio*, 1958. 5*s net*

Though the author-illustrator has 'not sought to keep up to date rocket-wise' nor 'to make factural predictions about the course of events', he has produced some spacecraft well calculated to stimulate the imagination and draughtsmanship of young people, accompanied by a text which unobtrusively conveys a good deal of information about space travel.

FROM THE JOURNAL OF 1858

VOLUME VI. *5th November*, 1858

ROCK SALT IN PRUSSIA

A correspondent of the *Daily News*, dating from Stettin, states that a discovery of the utmost importance for the trade of Prussia and the countries on the Baltic generally, has lately been made at a place called Strassfurt, near that city, consisting of an inexhaustible bed of pure rock salt. It is now some months since vague and uncertain reports of the discovery were circulated there, but they were at first discredited, on the ground that the geological features of Pomerania, being of alluvial and diluvial formation, were not of a nature to cover a large deposit of salt, although it was known that there are, in many parts of the province, saline springs which are used by the government for the artificial manufacture of salt.

The fact of the discovery is, however, now stated to be well authenticated. A small cargo has been sent this summer to Scotland, to be used in salting herrings, and the quality is said to be even superior to the Liverpool rock salt. As these salt beds are of very considerable extent, and from their proximity to the sea, the produce can be raised and shipped at a very low figure, the discovery is likely to bring about an important revolution in the salt trade, which, in Prussia, is a government monopoly; indeed, the Minister for Commerce has, in consequence of the discovery, ordered the saline works at Colberg and Cösen to be discontinued, it being found impossible to compete profitably, by any artificial means, with this prolific natural store. Government has fixed the price for the present at six silbergroschen per centner (equal to about 11*s* sterling per ton), delivered free on board at Strassfurt, which is about the shipping price at Liverpool. It is, however, thought probable that a great reduction will take place, as the actual cost of production only amounts to one-fourth of the above figure.

Some Activities of Other Societies and Organizations

MEETINGS

THURS. 30 OCT. Kinematograph Society, British, at Century Theatre, Soho Square, W.1. 7.30 p.m. G. Pearson, J. Huntley and J. Harris: *Changing styles of film editing.*

FRI. 31 OCT. Radio Engineers, British Institution of, at Edinburgh University. 7 p.m. H. G. Hinkley: *Flight evaluation of airborne electronic equipment.*
At Winter Gardens, Malvern. 7 p.m. E. N. Shaw: *Thermal Design.*

MON. 3 NOV. Engineers, Society of, at Burlington House, Piccadilly, W.1. 5 p.m. Capt. G. S. Ritchie: *Hydrography.*
Modular Society, at The Building Centre, Store Street, W.C.1. 6 p.m. Annual general meeting and exhibition of members' work.
Petroleum, Institute of, at 61 New Cavendish Street, W.1. 5.30 p.m. A. F. Fox: *Some problems of petroleum geology in Kuwait.*

THURS. 6 NOV. Analytical Chemistry, Society for, at The University, Oxford Road, Manchester. 7.15 p.m. J. M. Bather: *The chemical examination of textiles.*
Electrical Engineers, Institution of, Savoy Place, W.C.2. 5.30 p.m. T. S. Pick and A. Readman: *The recognition of moving vehicles by electronic means.*

FRI. 7 NOV. Royal Institution, 21 Albemarle Street, W.1. 9 p.m. Trenchard Cox: *The history of the Victoria & Albert Museum and the development of its collection.*

MON. 10 NOV. Commonwealth Institute, South Kensington, S.W.7. 5.45 p.m. T. M. Kodwo Mercer: *The new Ghana.*
Geographical Society, Royal, 1 Kensington Gore, S.W.7. 8.30 p.m. Dr. Paul Siple: *South Pole station.*

TUES. 11 NOV. Chemical Engineering Group, at Society of Chemical Industry, 14 Belgrave Square, S.W.1. 6 p.m. W. B. Wright and W. Elland: *The integrated iron and steel works.*
Chemical Engineers, Institution of, at College of Science and Technology, Jackson Street, Manchester. 6 p.m. D. M. Elliott and R. Parkins: *The design and operation of refrigeration plant in the chemical industry.*
Mechanical Engineers, Institution of, 1 Birdcage Walk, S.W.1. 6 p.m. T. C. F. Stott: *Fatigue testing of vehicle components.*

WED. 12 NOV. Engineering Inspection, Institution of, at Royal Society of Arts, John Adam Street, W.C.2. 6.15 p.m. E. D. van Rest: *Is quality control different from inspection?*

THURS. 13 NOV. Kinematograph Society, British, at Royal Society of Arts, John Adam Street, W.C.2. 7.30 p.m. John Hadland: *High speed cinematography.*

MON. 17 NOV. Commonwealth Institute, South Kensington, S.W.7. 5.45 p.m. Miss G. N. Commander: *Commonwealth journey.*
Illuminating Engineering Society, at Lecture Theatre, S.W. Electricity Board, Bristol. 7 p.m. F. P. Bentham: *The stage and the lighting engineer.*
Transport, Institute of, at 66 Portland Place, W.1. 5.45 p.m. A. Clifford Hartley: *Transportation by pipeline.*

THURS. 20 NOV. Road Transport Engineers, Institute of, at Royal Society of Arts, John Adam Street, W.C.2. 6.30 p.m. D. H. Whyke-Smith: *Taking stock on maintenance.*

OTHER ACTIVITIES

NOW UNTIL SAT. 1 NOV. Royal Academy of Arts, Burlington House, Piccadilly, W.1. 10 a.m. to 5.45 p.m. Exhibition of work by the students of the Royal Academy Schools.

NOW UNTIL SAT. 1 NOV. Wood Engravers, Society of, at The Crafts Centre, Hay Hill, W.1. 10 a.m. to 5 p.m. Sats. 10 a.m. to 12.30 p.m. Exhibition: *Wood engravings and colour prints.*

THE SOCIETY'S CHRISTMAS CARD, 1958

The subject of the card, painted in full colour by Miss Anna Zinkeisen, R.O.I., R.D.I., is the planting of acorns by the fifth Duke of Beaufort on his Gloucestershire estates in 1758. For this work the Duke received the Society's gold medal—the first of its many awards made to promote reafforestation in Great Britain.

The card is produced specially for Fellows of the Society. It is $7\frac{1}{2}'' \times 6''$, includes a description of the picture and bears the greeting: *With All Good Wishes for Christmas and the New Year.* Space is allowed for overprinting the sender's name and address if required.

PRICES FOR FELLOWS RESIDENT IN THE UNITED KINGDOM

15/6 per dozen for the first four dozen.
14/6 per dozen thereafter.
1/6 each for orders of less than one dozen.

Additional cost of printing name and address :
15/- for four dozen or less.
1/6 per dozen thereafter.

PRICES FOR FELLOWS RESIDENT OVERSEAS

14/- per dozen.
1/3 each for orders of less than one dozen.

Additional cost of printing name and address :
12/- for four dozen or less.
1/- per dozen thereafter.

All prices include envelopes and postage at ordinary rates. Cards can be sent by air mail, if requested, at the appropriate additional cost.

PLEASE USE THE ORDER FORM OVERLEAF

ORDER FORM

To the Secretary,

THE ROYAL SOCIETY OF ARTS, JOHN ADAM STREET, ADELPHI, W.C.2.

I wish to order...Christmas cards.

(*and to have my name and address printed as instructed below). A remittance for..is enclosed in accordance with the prices quoted overleaf. (* and includes the necessary amount .

Name ....

Address to which cards are to be despatched :—

....

....

....

....

* Delete if printing of name and address is not desired

INSTRUCTIONS FOR PRINTING NAME AND ADDRESS

(Please write in block capitals and give exact wording and punctuation required.)

Name(s)..

Address ....

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